THE

TEA QUARTERLY

THE JOURNAL

OF THE

TEA RESEARCH INSTITUTE

OF CEYLON.

VOLUME I.

1928.

Edited by

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THE TEA RESEARCH INSTITUTE

NUWARA ELIYA.

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FOREWORD.

During the last two years, it has been repeatedly urged by different District Planters' Associations that the Tea Research Institute should publish an independent Quarterly Journal which should incorporate the work of the scientific staff and their views on questions of interest to the tea planter. With that demand we have always been in complete agreement, and we have pleasure in presenting this, the first number of the Tea Quarterly.

It will be the aim of this journal to bring to the notice of the Ceylon tea planters everything relating to tea which is likely to be of interest to them or of assistance in their work. It will, naturally, contain articles by the staff of the Tea Research Institute dealing with the investigations which they are carrying out in the laboratory or the field, and short notices on special features of interest which may be met in the course of advisory correspondence and estate inspection, as well as general articles in scientific agriculture as applied to tea, especially on points which are, at the moment, the subject of discussion among the planting community.

In addition, endeavours will be made to include critical reviews of work done on tea in other countries. Ceylon, in the early days of planting in the tropics, supplied information regarding our chief products to countries where the planting industry was not so advanced. But other countries have now entered this field, with a wealth of scientific assistance such as the British Empire has not yet imagined, and the volume of information published in other languages, most of it a sealed book to the British planter, is now greatly in excess of that published in English. We hope to break through this splendid isolation and present these results to our readers.

In brief, the Tea Quarterly will aim at providing a summary of all the available information relating to the cultivation and manufacture of tea, and will thus endeavour to fill a gap which at present exists in the agricultural literature of the British Empire.

Contributions from our planting readers will be welcomed. These should deal with actual experiences and results obtained in practice.

We would ask our readers to take extra care in filing the numbers of the Journal for future reference. It may lighten the work of the staff if they are able to refer correspondents to information in previous numbers of the Journal. We make this suggestion in the hope that it will be considered superfluous, but experience has shown that it is extremely rare to find a complete set of any Ceylon publication in Ceylon.

TEA AND SOIL ACIDITY.

Water Culture Experiments, I.

By

C. H. GADD, D. Sc. (BIRM.).

The nutrition of a plant is affected by many factors other than the presence of particular nutrients in the soil. These factors are so completely interdependent that it is unwise, when considering nutrition, to think of the soil as apart from the plant and climate. It has been recognised from classic times that different species of plants require different conditions for optimum growth, and that certain plants are indicative of conditions of the soil in which they grow. The suitability of a soil for a particular agricultural purpose may often be determined with greater accuracy from the presence of certain plants growing on it than from an elaborate chemical analysis. The presence of bracken in patana land is regarded in Ceylon as indicative that the soil is suitable for tea cultivation. Though such a criterion may be of great value to agriculturists when selecting areas for tea cultivation, a more detailed knowledge is required of the particular requirements of the tea bush if the soil fertility is to be maintained or increased.

It is well known that acids have an inhibiting effect on the growth of many bacteria and a favourable effect on the growth of fungi. There is also abundant evidence that acidity of the soil is closely connected with the distribution of wild plants. Some species grow by preference upon limestone and similar soils; others appear to avoid calcareous soils. It is not surprising, therefore, that cultivated plants also have particular requirements as regards soil acidity. Potatoes and oats thrive in acid soils, while other crop plants, *e.g.*, alfalfa, may die in an acid soil no matter how fertile.

The use of lime for the correction of soil acidity is amongst the oldest of agricultural operations. The correction or adjustment of soil acidity to an optimum value for a permanent crop, like tea, necessitates an exact knowledge of the plant's requirements in this particular. A general statement such as "Tea does not require lime" is insufficient, because, although tea may prefer an acid soil, it is possible that some soils may be improved by an application of lime, while others, being insufficiently acid, may be benefited by some treatment which will increase their acidity.

The characteristic sour taste—from which the term "acid" was originally derived—is dependent more upon the strength of the acid than upon its quantity. When considering soil acidity in relation to

plant growth, the *strength* of the acid in the soil solution, *i.e.* the hydrogen-ion concentration of the soil, is of greater importance than the *quantity* of acid as measured by titration. Two solutions of different acids may require equal quantities of alkali to neutralise them, but the one, *e.g.* Hydrochloric acid, of which a greater percentage is ionised and which, consequently, has a greater hydrogen-ion concentration, is more strongly acid than another, *e.g.* Formic acid, which is ionised to a much smaller extent.

It is unnecessary to consider here the different theories which have been put forward to account for the phenomenon termed soil acidity. Nor is it necessary to define more accurately what is meant by hydrogen-ion concentration or to explain the methods of its measurement. It will perhaps be sufficient for our present purpose if it is understood that hydrogen-ion concentrations are commonly expressed in terms of what is known as the pH scale.

The hydrogen-ion concentration of pure water has a value of 7 (approx.) in the pH scale and this value may be interpreted as neutrality. The lower the pH value the greater is the degree of acidity; the higher the value above 7 the greater is the alkalinity. It should also be noted that the scale is a logarithmic one and, as on a slide rule, begins at 1 not 0. A pH value of 2 represents a hydrogen-ion concentration 10 times greater than a pH value of 3 and 100 times greater than one of 4, and so on. A solution with a pH value of 5 is therefore 100 times more acid than another with a pH value of 7. Similarly water (pH = 7) may be regarded as 10 times more acid than an alkaline solution with a pH value of 8.

In order to ascertain the effect of acidity (hydrogen-ion concentration) on the development of the tea plant, seedlings were grown in water culture solutions of various pH values. Before the actual experiment started, the seedlings were grown in a standard solution for six weeks. Each plant was provided with about 500 c.c. of solution, and light was excluded from the roots. The cotyledons (seed) were removed from the plants in order that any reserve food remaining in them would have no influence on the experiments. At the end of this preliminary period the plants were arranged in five pairs, and each pair was provided with water culture solution of a different pH value. A standard solution was used for all plants; sulphuric acid was used to increase the acidity, and sodium hydrate to render the solution alkaline. The pH values selected were 3·5, 4·5, 5·5, 6·5, and 7·5.

The plants were weighed at the beginning of the experiment and at intervals of three weeks, at which times the plants were provided with fresh solutions. After 9 weeks (Dec. 1st, 1926 to Feb. 2nd, 1927) the experiment was temporarily stopped and all plants were placed in tap water which had been filtered through a Berkfeld filter,

In Table A are given the initial and final weights of each pair of plants for this period. It will be noticed that the plants grown in the solution with a pH value of 3·5 showed the greatest increase in weight, viz., 2·52 gms. As the plants were not of equal size at the commencement, it is preferable to compare the increases on a percentage basis, calculated on their initial weights. These are given in the same table. The smallest increase was made by the plants grown in the solution at pH 5·5. Except for this result there is a direct correlation between growth (as shown by increase in weight) and the degree of acidity of the solution, the better growth occurring in the more acid solutions.

Table. A. First period (December 1st, 1926—February 2nd, 1927.)

Plants No.	pH Solution.	Initial Weight gms.	Final Weight gms.	Increase gms.	Increase per cent.
1	3·5	5·70	8·22	2·52	44·3
2	4·5	6·56	8·43	1·87	28·5
3	5·5	7·03	8·34	1·31	18·7
4	6·5	7·62	9·36	1·74	22·8
5	7·5	6·58	7·86	1·28	19·4

Table. B. Second period (March 3rd—March 30th, 1927.)

Plants No.	pH Solution.	Initial Weight gms.	Final Weight gms.	Increase gms.	Increase per cent.
1	6·5	8·78	10·12	1·34	15·3
2	7·5	9·32	10·50	1·18	12·7
3	5·5	8·96	9·40	0·44	4·9
4	3·5	10·29	12·81	2·52	24·4
5	4·5	8·31	11·10	2·79	25·1

After the plants had remained in filtered tap water for 4 weeks they were replaced in the culture solutions. This time, however, the plants which were previously in the solution at pH 3·5 were transferred to that at pH 6·5, and the plants from the pH 6·5 solutions were placed in that at pH 3·5. Similarly, the plants from the solutions at pH 4·5 and 7·5 were also exchanged, but those previously in the solution at pH 5·5 were replaced in the same solution. The seedlings were allowed to remain in these solutions for 12 weeks (March 3rd to May 30th, 1927) under similar conditions as before. The results obtained during the second period act as a check on those of the earlier period.

It will be seen from Table B, in which are given the initial and final weights of each pair of seedlings for this period, that the plants which previously made poor growth in solutions at pH 6·5 and 7·5 showed the largest increases in weight after they were transferred to more acid solutions. Similarly, the rate of growth of the plants which were, during the first period, in the acid solutions with pH values of 3·5 and 4·5 fell off after they were transferred to solutions with pH values of 6·5 and 7·5. These reversals can only be due to the change of acidity of the culture solutions, and they indicate clearly that tea seedlings require an acid medium for optimum growth.

The poor growth shown by the plants in the culture solution at pH 5·5 was unexpected. As these seedlings were maintained for the whole experiment in the same solution, except for the 4 week interval between the two periods, there must remain some doubt whether their weak growth was due solely to a detrimental effect resulting from an unsuitable degree of acidity. Tea grows well, as a rule, in soil with a pH value of about 5·5. This gives rise to the suspicion that some other factor had a detrimental effect on these plants. Consequently, it is advisible to leave them out of consideration, and to compare only the more acid solutions with those approximating neutrality.

Increase in weight was not correlated with the increase in number of leaves nor with elongation of the stem. Plants which made the largest increase in weight did not necessarily produce the greatest number of new leaves during the course of this experiment.

The experiment showed, however, that pH values of 6·5 and 7·5 tend to induce the production of smaller and yellower leaves, whereas the lower (more acid) values, 3·5 and 4·5, result in the development of normal green leaves. This fact may be illustrated by the following instances. One plant, grown first in the solution at pH 7·5 and later in that at pH 4·5 developed five new leaves. The first expanded while the plant was in the pH 7·5 solution and the second while in filtered tap water. These leaves were yellow and smaller than usual. The remaining three leaves were produced while the plant was in the solution at pH 4·5. These were normal in size and dark green in colour. Another plant, while in the solution at pH 6·5, produced three new leaves; these were sickly and successively smaller. Two fell off before the end of the experiment. After the plant was removed to the solution at pH 3·5 it expanded five more new leaves. These were successively larger and greener in colour.

The most marked effect of the differing degrees of acidity of the solutions was to be seen on the root growth. In solutions at pH 3·5 and 4·5, good root growth was made; numerous new rootlets were developed and these appeared white and healthy. In the less acid solutions no new roots were produced, and the existing rootlets turned brown. After the change over to more acid solutions, the plants with dead rootlets developed new ones which remained white and healthy. When transferred to solutions approximating neutrality the healthy young roots turned brown and flaccid after a short time.

These conditions are well shown in the accompanying photographs. Fig. 1 (Plate 1) is a photograph of the root system of a plant grown in the solution at pH 4·5. Note the young white roots amongst the dead ones. This plant had previously been grown in a solution at pH 7·5 when all the roots had turned brown and flaccid and resembled

those shown in Fig. 2. All the new root growth was made while in the acid solution at pH 4·5. Fig. 2 is of a plant first grown in a solution at pH 4·5 when it had a root system with white healthy roots similar to that shown in Fig. 1, but after transference to the solution at pH 7·5 all the roots turned brown and no new root-growth was made.

As the plants were grown for the purpose of these experiments in water culture solutions, *i.e.*, under unnatural conditions, no very great importance should be attached to any optimum pH value which might be calculated from these experiments. They demonstrate clearly, however, that the growth of tea seedlings can be controlled to a large extent by alterations in the hydrogen-ion concentration of the medium surrounding the roots, and that pathological symptoms, as shown by root-growth and the yellowing and dwarfing of leaves, can be induced with solutions approximating neutrality, and corrected when the acidity of the solution is increased.

Further details of these experiments will be communicated in a later article.

ARTIFICIAL FARMYARD MANURE.

By

T. PETCH,

In the era of coffee in Ceylon, manuring consisted principally of the application of cattle manure, herds of cattle being maintained for the purpose. In the early days of tea planting, the practice was continued, but except for a few estates upcountry it has now been practically abandoned as far as tea is concerned, though it is still in vogue, in one form or another, on coconut and cacao estates. The principal difficulties in the way of the employment of cattle manure are the absence of convenient areas of pasture land and the cost of transport of such bulky material by coolie labour. Consequently the tea planter relies on artificial fertilisers, with organic material in the form of poonacs.

It is, however, generally recognised that artificial fertilisers are not a complete substitute for farmyard manure. Russell states "farmyard manure behaves differently from artificial manures and is not wholly replaceable by them;" and in discussing the famous Rothamsted experiments, he writes " For the first few years the artificials considerably enhanced the fertility of the soil, but after a time their effect began to fall off. Farmyard manure, on the other hand, showed a smaller falling off, and though, both at Rothamsted and Woburn, it began by being less effective than artificials it was finally more effective; the difference has now become rather marked."

PLATE I.

Fig. 1.
Root system of a tea seedling grown in a culture solution at pH 4.5

X 3/5

Fig. 2.
Root system of a tea seedling grown in a culture solution at pH 7.5.

X 3/5

This superiority of farmyard manure is to be attributed not so much to the nitrogen and mineral substances it contains as to the organic matter, the decaying vegetable matter of which it is chiefly composed. The vegetable matter increases the humus content of the soil, and so alters its physical composition and possibly its bacterial flora. Humus alters the character of the soil and assists it to retain moisture, so that crops grown with farmyard manure are less liable to suffer from seasonal variations than those grown with artificials only.

In Ceylon, this defect of artificial manures is being avoided by the practice of green manuring, which has been steadily extending during the last twenty-five years. Although this practice was originally introduced into Ceylon with the idea of utilising atmospheric nitrogen by the agency of leguminous plants, and is still often discussed from that standpoint only, it is now realised that one of the important functions of a green manure is the addition of humus to, and the consequent improvement of the condition of, the soil.

During recent years, scientific investigations have shown the possibility of converting vegetable refuse, without the intervention of animals, into an "artificial farmyard manure," and this process is now being tried out in different parts of the world, under widely different climatic conditions. Our readers will be familiar with the accounts of these trials in other countries which have already been published, but it appears worth while to record the following details concerning an experiment in the manufacture of artificial farmyard manure in Ceylon.

The experiment in question was carried out by Mr. P. G. Boileau, of Dunkeld Estate, who has kindly furnished the following particulars. The analyses were executed by the firm of Bamber and Bruce.

Approximately 8 tons of material (mostly Mana grass) was placed in a pit at the beginning of February, 1927. Nitrolim was used as a starter. Water was added at the rate of approximately 125 gallons per ton when the pit was first filled, and subsequently at the rate of about 12 gallons per ton per day in dry weather.

During the dry weather the pit was left uncovered, and watered daily. During the wet months it was covered.

The result of an analysis of the material made in July, 1927 was as follows.

Moisture lost in the sun, 66·6%		Sundried material.		Original material.
Moisture lost at 100°C.	...	6·7%	...	68·84%
Ash	...	56·4%	...	18·84%
Organic matter	...	36·9%	...	12·32%
		100·00	...	100·00
		Sundried material.		Original material.
Nitrogen in the organic matter	...	0·8 %	...	0·27%
Phosphoric acid in the ash	...	0·48%	...	0 16%
Potash in the ash	...	0·63%	...	0·21%
Humus	...	2·4 %	...	0·80%

The degree of humification is small, amounting to only about 6·5%, and probably indicating that sufficient time had not elapsed for the manure to mature.

Another analysis, of material taken from the same pit five weeks later, yielded the following results.

Moisture lost in the sun, 50·4%.		Sundried material.		Original material.
Moisture lost at 100°C.	...	11·00%	...	55·85%
Ash	...	34·78%	...	17·24%
Organic matter	...	54·22%	...	26·91%
		100·00	...	100·00
Nitrogen in the organic matter	...	1·26%	...	0·63%
Phosphoric acid in the ash	...	1·02%	...	0·51%
Potash in the ash	...	0·60%	...	0·29%
Humus	...	13·08%	...	6·04%
Nitrates	...	nil	...	nil
Degree of humification	...	24·12%	...	24·12%

The percentage of ash in these samples may be due, in part, to the accidental inclusion of soil from the sides of the pit when it was being filled.

For the sake of comparison, we reprint analyses of artificial farmyard manure, made by the pit system at Peermade (South India) using lemon grass, with nitrolim as a "starter," and of similar manure, made by the heap system in Trinidad, using dry grass, with Adco reagent. On the natural sample, these are as follows.

		Dunkeld. %		Peermade. %		Trinidad. %
Moisture lost at 100°C.	...	55·85	...	73·03	...	77·38
Ash	...	17·24	...	13·44	...	6·86
Organic matter	...	26·91	...	13·53	...	15·76
		100·00		100·00		100·00
Nitrogen in the organic matter	...	0·63	...	0·30	...	0·51
Phosphoric acid in ash	...	0·51	...	0·095	...	0·81
Potash in ash	...	0·29	...	0·047	...	0·26

Calculated on the dry weight at 100°C., these become

		Dunkeld. %		Peermade. %		Trinidad. %
Ash	...	39·05	...	49·83	...	30·33
Organic matter	...	60·95	...	50·17	...	69·67
Nitrogen in the organic matter	...	1·42	...	1·11	...	2·25
Phosphoric acid in ash	...	1·15	...	0·34	...	2·69
Potash in ash	...	0·65	...	0·17	...	1·15

The question has arisen, in what quantity artificial farmyard manure should be applied to tea. This is naturally a matter for field experiment, but assuming that artificial farmyard manure behaves in exactly the same way as natural farmyard manure, there is one point which must be borne in mind when considering the equivalent values, as regards nitrogen content, of artificial farmyard manure and the manure mixtures in general use; and that is their difference in rate of availability.

In temperate climates, the nitrogen in (real) farmyard manure is available much less rapidly than that in dried blood or poonac.

Roughly the nitrogen in farmyard manure is available about half as rapidly as that in dried blood, cotton seed poonac, or green vegetable matter. Consequently farmyard manure ranks among the slow-acting manures, and where annual crops are grown, its nitrogen, in general, is not all consumed by the plant in the first year. Its effects are not confined to the season of application, but persist over several years. Hence when a farmer gives up his farm, he is compensated for the unexhausted value of the manure, and it is customary, in the second year after its application, to allow one-quarter the value of the nitrogen originally in the manure.

The bearing of this on the application of artificial farmyard manure to tea will be evident, if we assume that its behaviour in the tropics is similar to that in temperate climates. The manures usually applied to tea are relatively quick-acting manures. If it is desired to obtain the same effect by manuring with artificial farmyard manure, it is not enough to apply that quantity which will give an equivalent amount of nitrogen, since part of this nitrogen will not become available in the same time as the nitrogen in the customary manure mixture. Nor is it economic to increase the quantity of the artificial farmyard manure. It will be necessary to supplement the latter with some quick-acting source of nitrogen.

Among the difficulties confronting the use of artificial farmyard manure on the average tea estate in Ceylon are (1) the absence of suitable material on the estate, (2) the area required for its preparation, (3) the labour required for the transport of the manure. As regards the latter, it may be noted that on the first Dunkeld analysis approximately 5 tons of manure are required to supply 30 lbs. of nitrogen.

It would seem that the combination of artificial fertilisers and green manures, at present in vogue on Ceylon estates, affords a more practical solution of our manuring problems than the use of artificial farmyard manure. But the latter might prove of great value on areas on which green manures cannot be grown.

THE PARASITISM OF TEA ROOT DISEASE FUNGI.

By

T. PETCH.

Among the commonest root diseases of tea in Ceylon are those caused by *Poria hypolateritia*, *Fomes lamaoensis* (Brown root disease), *Ustulina zonata*, and *Rosellinia arcuata*. *Fomes lignosus*, the well-known cause of the most widely distributed root disease of rubber (Hevea), rarely attacks tea in Ceylon, though one of the most serious outbreaks of *Fomes lignosus* on rubber in Ceylon occurred on an estate where rubber had been planted through tea, and the tea cut off at ground level when the rubber was mature. In that case, *Fomes lignosus* developed on the tea stumps and spread from them to the rubber over about 150 acres.

Some of these diseases have a long history. Brown root disease was first recorded on breadfruit trees in Samoa in 1875, and again from the same country on cacao in 1895 and 1907. Cunningham found it on tea in India in 1887. Zimmermann recorded it from Java in 1904, and it was identified in Ceylon in 1905. Since then it has been recorded from the Federated Malay States, Burma, and West Africa.

In general, Brown root disease has been identified by its mycelium, since, in most countries, the fructification of the fungus has not been found. Consequently, there is a possibility that the name may cover more than one disease, as there must always be a doubt when a fungus from one country is identified as the same as a fungus from another country from mycelium only. The mycelium of Brown root disease has peculiarities, but it is quite possible that the mycelium of some other fungi may have the same peculiarities. A fructification of the Ceylon Brown root disease has been found repeatedly during the last ten years, and there is no doubt that, in this country at least, the most frequent Brown root disease, if there is more than one, is *Fomes lamaoensis*. But until the fructifications of the " Brown root diseases " of other countries have been discovered, there is room for doubt whether they are the same.

One species of Poria was recorded as the cause of a root disease of tea by Zimmermann in Java in 1901, a group of one hundred bushes, two and a half years old, being killed, but it is uncertain whether his account refers to *Poria hypolateritia*, the commoner Ceylon species on tea, or to *Poria hypobrunnea* which is rare on tea but fairly common on rubber. The former was first recorded in Ceylon in 1907, though there is a little doubt that it has been the common tea root fungus on new clearings since 1880. It is known to occur also in India.

Rosellinia arcuata was recorded, as the cause of root disease in tea, by Carruthers in 1903. It also causes root disease of tea in India and Java. Species of similar habit occur in the West Indies and other parts of the world, and have long been recognised as the causes of root (or collar) disease in Europe, America, and New Zealand.

Ustulina zonata was first observed to be parasitic in Ceylon in 1907. Since then it has been found to attack numerous species of woody plants in India, Burma, Java, and the Federated Malay States.

Fomes lignosus was first found as a cause of root disease on rubber at Singapore, and was recorded by Ridley in 1904. Since then it has been recorded from all the rubber-growing countries of the eastern tropics, as well as from Africa, and has been universally accepted as the cause of the most serious root disease of rubber in the eastern hemisphere. It is also known to attack many other woody plants.

Proof of the parasitism of *Fomes lignosus* on woody plants was given by Bancroft. Rubber seedlings, three months old, were transplanted into boxes. In four cases, a piece of a root infected with *Fomes lignosus* was placed in contact with the roots of the seedling. Two other plants were left as controls. Of the four plants whose roots were in contact with an infected root, three acquired the disease, the fourth remaining healthy because the mycelium of the fungus failed to grow out from the infective material.

Two other experiments were carried out by Bancroft on similar lines. Attempts were made to infect fourteen plants, and of these ten were successful.

As regards Brown root disease, Anstead has recorded an experiment in South India in which a root attacked by Brown root disease was buried in contact with the roots of a healthy rubber tree, with the result that the latter was infected and died.

In Ceylon, tea roots bearing the mycelium of *Poria hypolateritia* have been buried in contact with the roots of tea bushes, and the mycelium has spread to the latter and killed them.

Anyone who has any doubt about the parasitism of these fungi can repeat these experiments in the field. In the case of rubber (Hevea) the diseased roots should be buried in contact with healthy roots an inch or two in diameter.

The objection may be raised that in these proofs the infecting material was a root which had acquired the disease naturally, and in such circumstances more than one fungus may have been present in the diseased root. It is well-known that, in general, when a plant is attacked by a disease, other fungi may subsequently develop on the dead tissues. But if any fungus which it is suspected might have been present in the infecting material has been proved incapable of

passing to healthy roots from diseased roots in contact with them, that fungus is definitely excluded as a possible cause of the disease.

A further objection that might be brought forward is that these proofs do not conform to modern standards in that the infections were not made from pure cultures. As will be admitted by most mycologists, that is not a disproof of their validity.

The earlier determinations of the causes of plant diseases were based on field observations, together with infection experiments with diseased material, such as those described above, or with spores produced in nature,—to which the same objection applies. That method is still employed in very many cases, as it is not always possible, in the present state of our knowledge, to grow a particular fungus in pure culture.

It is worth noting that the majority of these old determinations still stand. Modern technique has only resulted in confirming them. Where this modern technique has added to the number of fungi which are known to cause diseases of plants is chiefly in cases in which no cause could be assigned by the older methods of investigation.

Following on the development of bacteriological technique, it was found that fungi could be grown on artificial or sterilised media in test tubes or flasks, with the assurance that only one fungus was present; and during the current century it has become customary to confirm, or to attempt to confirm, field observations, by infections from such "pure cultures." This, however, is not always successful, as it is not always possible to reproduce, by laboratory methods, what actually occurs in nature.

Our root disease fungi afford a case in point. Our common root disease fungi belong to the group known as facultative parasites, that is, they are not always parasitic, but can either live as saprophytes on dead plant tissue or can attack healthy plants. In general, the fungi of our root diseases begin to grow, on estates, as saprophytes on jungle stumps or the stumps of trees which have been planted as green manure or shade trees and felled when it was desired to get rid of them. The infection of these stumps is brought about by spores of the fungus which are carried by wind.

After the fungus has grown in the stump for some time,—it may be a few months or even years,—and has reduced it to a state of decay, it spreads to the cultivated plants, sometimes by means of free strands of mycelium, sometimes by contact of the roots of the cultivated plants with the lateral roots of the stump. Frequently, it forms strands or masses of mycelium on the exterior of the root of the cultivated plant before penetrating it. It is for the latter reason that it is sometimes possible to deal with early cases of *Fomes lignosus* on Hevea by scraping off the mycelium and painting the root with a fungicide.

[It may be observed, to avoid misunderstanding, that although infection by way of stumps is certainly the more general mode of occurrence of our root diseases it is not the only one. Fungi are propagated by spores, and there is no reason why these spores should not infect plants directly. Occurrences of root disease on isolated bushes, not in the neighbourhood of stumps, are no doubt due to infection by spores.]

The point to be particularly noted is that when the fungus begins to spread from the stump, it has an accumulated reserve behind it, and it is for that reason that it is able to spread through the soil free, not in contact with anything from which it can obtain food, and can develop its mycelium over the root of its victim before it penetrates it.

It is not possible to imitate those conditions from pure culture. If the fungus is grown in pure culture on agar, the amount of mycelium which can be used for inoculation is small, and the agar substratum usually soon disappears. If, on the other hand, the fungus is grown in pure culture on sterilised wood blocks, a similar difficulty is encountered. The volume of a block of wood which can be sterilised with certainty is small; about one cubic inch is usual. Moreover, although a vigorous growth of mycelium may occur, it will be found that this is chiefly external, and unless the cultures are allowed to develop for a long period, there will be little penetration of the wood block.

Consequently the conditions which obtain when infections with our root disease fungi are attempted from pure cultures, when the mass of infecting material is comparatively small, are quite different from those which occur in nature, where the advancing fungus has behind it a stump which may weigh anything up to several hundredweights. Hence one should not be surprised if attempts to infect our estate plants from pure cultures of such fungi as *Fomes lignosus*, *Poria hypolateritia*, etc., are unsuccessful, in spite of the fact that these diseases are readily communicated by diseased roots.

It is not intended to maintain that these diseases cannot be communicated from pure cultures, but merely to point out some of the difficulties in the way. The use of pure cultures is to confirm field observations. But the failure of the pure culture method does not necessarily refute field observations.

We have dealt with this question of pure cultures, as it concerns our root diseases, as briefly as possible. The tendency of much of our present day mycology is to make a fetish of pure cultures and to reject the evidence of field observations,—to believe nothing which cannot be reproduced by laboratory methods.

Infection experiments with *Ustulina zonata* were carried out on Hevea by Brooks and Sharples in Malaya. In one series of experi-

ments, by Brooks, in which seedling rubber plants in pots were used, blocks of wood on which the fungus was growing in pure culture were placed against the root, in three cases after wounding the root and in three others without wounding. Of the former, two plants were successfully infected, but of the latter only one. The experiment was repeated on fourteen four-year-old trees in the field, eight of which were wounded down to the wood, while six were not wounded. All the wounded trees were successfully infected, but there was only one, and that doubtful, infection among the six unwounded trees.

Sharples, using the same method, succeeded in infecting twelve rubber trees out of eighteen inoculated, the inoculations being made on wounds.

According to the foregoing experiments, *Ustulina zonata* is a wound parasite on Hevea, *i.e.*, it can only attack the tree through a wound. But field observations clearly show that that is not the whole truth. Cases have been observed in which it has been quite clear that the Hevea has been infected on the tap root just below the laterals by contact with a diseased root of an Albizzia. This illustrates the point already mentioned,—the difficulty of reproducing, by means of the comparatively small amount of mycelium available from pure cultures, what readily happens in nature by contact with a diseased root.

Similarly as regards tea. *Ustulina zonata* is a wound parasite, when the spores infect the top of the stump,—the exposed wood in the middle of the bush,—and the fungus grows downwards, killing the bush. But Ustulina more usually attacks the roots of the tea bush, spreading to them from some neighbouring stump, and there is no doubt that in these cases it does not require that the root shall have been previously wounded. When, twenty years ago, it was a common practice to fell Grevilleas and leave their stumps to decay, it was usual to find lines of dead tea bushes along the decaying lateral roots of the Grevillea, and it was quite easy to determine that the fungus spread from the Grevillea root to the tea root by contact, and that the tea roots had not been previously wounded.

Experiments which demonstrate the parasitism of *Rosellinia arcuata* will be published in a subsequent number of this journal. But to anyone who has watched the spread of this Rosellinia in the field, infection experiments must be purely academic.

Almost my first experience of *Rosellinia arcuata* was its occurrence in a Panax hedge round my bungalow garden at Peradeniya. A mango tree which stood on the adjoining estate had been felled and the log left lying with one end near the hedge. The Rosellinia began to develop among the dead leaves which had accumulated alongside the log, and then spread to the hedge, where it ran along the surface

of the ground under and among the dead leaves in the hedge bottom. As the mycelium reached each of the closely-planted Panax stems, it enveloped it at the base. The cortex of the Panax stem rapidly became soft and rotten, and in a very short time that plant was dead. In a few weeks the hedge had been killed for a length of about six feet. It was then considered that sufficient information had been obtained concerning the method of progress of the fungus. The dead plants were dug out, together with two or three healthy plants at each end of the dead zone, all dead leaves raked up, and the whole burnt. About a year later, the gap was filled in the usual way by cuttings, and these, with the remainder of the hedge on either side of the gap, were alive and healthy when I left the bungalow eighteen years later.

A similar account is given of *Rosellinia radiciperda* in New Zealand. " In an orchard it will appear in patches, killing the fern and sorrel, and spreading until it reaches a fruit tree; it then attacks the bark round the stem just under the ground, which speedily rots, presenting the appearance of having been cooked, and has an offensive smell; it then proceeds along the roots, and the tree soon shows withered leaves, which drop off, leaving it bare." (Kew Bulletin, 1896, p. 2).

However, as stated above, proof of the parasitism of *Rosellinia arcuata* has been obtained and will be published at an early date.

The experiments recorded above, with *Fomes lignosus*, Brown root disease, *Poria hypolateritia*, and *Ustulina zonata*, can be repeated by any one who desires. At the present time they are accepted as definite evidence by nearly all mycologists who are acquainted with these fungi in the tropics.

SPHAEROSTILBE REPENS.

From the observations of Tunstall (Indian Tea Assoc. Sci. Dept. Quart. Journ., 1927, pt. II., pp. 69-71) it would appear that the fungus *Sphaerostilbe repens* occurs more frequently on tea in North-East India than it does in Ceylon. In Assam, the affected bushes become weaker year by year and ultimately whole areas die out. The roots when dug out frequently have a mauve or violet tint. The removal of a portion of the discoloured bark reveals white to orange-coloured bands of fungus mycelium ramifying over the wood just below the bark. In the dead portions of the root these bands become purplish black.

In Assam this fungus, *Sphaerostilbe repens*, has been found on the roots of Jak and many jungle trees which apparently have suffered no serious damage from it. It has also been found on the roots of vigorous and apparently healthy tea bushes. It would appear, therefore, that the fungus does not necessarily cause serious damage so long as conditions are otherwise favourable to the infected plants. The fungus is found to be mostly prevalent on badly aerated soils. In such places the tea bushes are attacked and damaged by the fungus, while on better aerated soil the bushes, though frequently attacked, show no apparent sign of damage.

In Ceylon, *Sphaerostilbe repens* is by no means uncommon, but its presence on tea is of extremely rare occurrence. It is well known as a saprophyte on felled dadap logs, chips of jak wood and such like material and is also known to cause root disease in several cultivated plants, *e.g.*, Hevea, papaw, cacao and arrowroot. When it occurs on the roots of living plants it is invariably associated with a diseased condition; the epiphytic state mentioned by Tunstall is unknown here. *Sphaerostilbe repens* is, therefore, regarded as a facultative parasite. In other words, it is primarily a saprophyte, but under suitable conditions it acquires a parasitic habit. Poor aeration and a more or less water-logged condition of the soil favour the development of the parasitic habit, and in this respect Ceylon experience agrees with the observations made in North-East India. Whether the parasitism of this fungus is dependent upon the reduced vitality of the tea resulting from the poor soil aeration, or whether such conditions strongly favour the growth of the fungus is perhaps of no great practical importance. The fact remains that there is little likelihood of this disease affecting tea seriously where efficient drainage and soil aeration are provided.

C. H. G.

HOW TO SEND IN SPECIMENS OF INSECTS FOR REPORT.

By

S. STUART LIGHT, A.R.C.S., D.I.C.

To avoid delay, insect pests sent to the Institute by post for identification and report should be packed in such a way that they will arrive in as good a condition as possible. Otherwise, it may be necessary to ask for further consignments before any decision can be arrived at.

The Entomologist would be most grateful if planters would, as far as possible, observe the following rules when sending insects by post.

1. Never put large numbers of insects in a box. Ample space should be provided, and few well-packed insects are usually sufficient.

2. *Live Specimens.*—Live insects are preferable to dead ones. If living insects are sent, they should always be provided with some packing material, such as tissue paper or newspaper, crumpled up or torn into pieces of suitable size, and packed loosely, so as to afford them a footing. Moss also forms a very suitable material. If possible, provide them with some of their natural food-plant.

3. *Nature of package.*—The covering in which they are despatched should always be of strong material. Do not send insects in envelopes or flimsy cardboard boxes, which are readily crushed in transit. In some cases such a proceeding is dangerous, since injurious insects may escape on the way, and infect fresh areas of tea.

Specimens of leaves affected by mites or minute insects can be sent very well in a cigarette tin, which preserves the moisture and keeps the leaves fresh. No air-holes need be provided.

Caterpillars and other leaf-eating pests should be sent in wooden boxes, if possible, instead of tins, since, owing to the moisture present, they are apt to become mouldy in the latter. Such boxes can be readily made up in the factory. Small holes should be provided for air-supply. Failing wooden boxes, strong cardboard boxes will often suffice.

Wood-boring insects, such as Shot-hole Borer and Red Borer, must be sent in tins, for obvious reasons. They should be provided with several pieces of the stem or root in which they normally live, and these should be wedged with paper to prevent movement in transit.

Chrysalides and soil insects should be sent in wood or cardboard boxes, loosely packed with some soft paper.

Glass bottles or tubes should be packed in a wooden box with cotton-wool, sawdust, or other packing material.

4. *Dead Specimens.*—If specimens are sent in a dead condition, the following rules apply.

Soft-bodied insects such as caterpillars, Tea Aphis, grubs of all kinds, and any soft, immature forms or minute insects should be put in bottles or tubes containing methylated spirits. In such cases the corks should be tightly fitting, and before sending should be either waxed or soaked in kerosense, to prevent the escape of the liquid. Failing methylated spirits, water containing a little ammonia or formalin will do in emergency.

Hard-bodied insects, such as beetles, fully-developed bugs, locusts, etc., travel well in a dried condition, but care must be taken to pack them well to avoid shaking in the post.

Butterflies and moths should be first killed either by the use of potassium cyanide or chloroform, or, more simply, by careful pressure of the body beneath the wings. They should then be placed, with folded wings, in oblong strips of paper folded over so as form a triangular envelope. These envelopes should be loosely packed in a box for despatch.

5. *Information accompanying specimens.*—Specimens sent in for examination should always be accompanied by a few words of explanation. The following details would be useful.

(*a*) The age of the plants attacked, and time from pruning.

(*b*) The maximum acreage attacked, and the area actually infested at the time of writing.

(*c*) The condition of the plants concerned, *e.g.*, "much defoliated," "flushing stopped," "bushes being thinned out," etc.

(*d*) The abundance of the insects present.

6. *Report on Treatment.*—Finally, if the treatment advised is adopted, it would be of great assistance if a report was furnished on the effects of such treatment. Data of this kind are of the utmost importance.

PESTS OF TEA NURSERIES; A WARNING.

By

S. STUART LIGHT, A.R.C.S., D.I.C.

On many occasions reports of various pests attacking seedling plants have been received which, on investigation, have shown the attack to be in such an advanced condition that the eradication of the pest or the saving of the remaining plants has been a well-nigh impossible proposition. This emphasises the fact that a large proportion of tea-planters are not familiar with the nature or the seriousness of the pests producing this damage, and as a consequence they neglect to report the occurrence until it has reached an alarming stage. It seems, therefore, that a useful purpose may be served by describing briefly the methods of attack of the chief nursery pests, so that some discrimination may be made between the several kinds, and by showing what precautions may be taken in order to save as many of the plants as possible from ultimate extinction.

The chief pests of tea nurseries in Ceylon are Eelworm, Scarlet Mite, Cutworm and Red Borer. These will be dealt with separately in that order.

Eelworm.—This pest is a minute, transparent worm, the male of which is worm-like in form, and lives freely in the soil. The female, on the other hand, is worm-like only in the earlier part of its life, soon boring into a root of a tea seedling and settling down to become a swollen, pear-shaped organism quite unlike a worm. In this condition it feeds on the tissues of the root, and finally produces a mass of eggs in the cavity of its body, which hatch into minute worms that escape into the soil, and wander about until they in turn enter the roots of a seedling.

The females alone cause the damage, and they alone are the means of infection of fresh plants.

Eelworm attack can be readily recognised by pulling up a few sickly plants. The roots, especially at the base, are noticeably swollen into galls or nodules, resulting from irritation of the tissues by the continued feeding of the female worms, which lie embedded in the tissues just beneath the surface.

Eelworm is indeed an important pest, capable, as it has often shown, of entirely exterminating a whole nursery of plants. A serious feature is that there is at present no known method, applicable to tea estates, of curing a plant already attacked by the worm. It therefore remains to take the matter in hand as soon as signs of eelworm appear in the nursery, and to do all that is possible to prevent the infection of the still healthy plants. The following method is

advised:—

Pull up and burn *all* plants in beds showing infection. Turn over the soil and fork in a good dressing of lime all over the beds. To protect the remaining beds, dig around them a trench 1 foot deep (the depth required depends on the construction of the beds) and about 6 inches wide; this should be packed with lime.

Although, as in the case of Shot-hole Borer, no method is known of satisfactorily destroying the pest without injuring the plants, a certain number of the infected plants frequently survive attack, and it is probable that a dressing of artificial manure (general mixture) may be of benefit to the healthy plants in helping them to resist attack, should they ultimately become infected. It is suggested that the manure be applied after the trench has been constructed.

Owing to the difficulty of determining the presence of eelworm in the soil, it is not easy to tell whether the earth in the proposed site for a nursery is already infected. For this reason it is advisable that the ground should be dug over and exposed to the air as long as possible before laying down a nursery. A minimum of one month is suggested, and during this period the earth should be forked over several times. Another precautionary measure is to pull up and examine the roots of various weeds growing in and around the proposed nursery. If these show signs of Eelworm, it may be taken for granted that the soil is infected.

Scarlet Mite.—This minute red mite feeds on the under sides of the leaves, attacking especially the base of the mid-rib, so that the leaf becomes constricted at that point, with the same effect as is produced by the normal leaf-fall of deciduous trees. Thus in the case of young seedlings bearing only a few leaves, it is frequently not long before they lose every leaf through the agency of Scarlet Mite. The typical appearance of seedlings attacked by Scarlet Mite much resembles the effect produced by eelworm. Half of the leaves have fallen, and the remainder are small and often distorted, the whole plant being so stunted in growth as to appear dwarfed when compared with normal, healthy plants of the same age. Infestation by Scarlet Mite may be distinguished by a brown discoloration at the back of the mid-rib, especially near the base, and, of course, the presence of the tiny scarlet mites themselves.

If the presence of this pest is spotted at an early stage, there is a much greater chance of saving the plants than in the case of eelworm, for it is believed that if the attack has not proceeded too far, the mites may be successfully dealt with by spraying, and the nursery ultimately saved. Infected plants should be sprayed thoroughly with a sulphur-soap mixture of the following composition:—

Flowers of sulphur	...	6 ozs.
Soft soap	...	1½ ozs.
Water	...	1 gall.

PLATE II.

Tea nursery destroyed by Eelworms. Surviving tea plants on upper right; remainder of nursery fern only.

The soap is dissolved in a quart of water (hot), and with this the sulphur is worked up into a paste, which is then stirred up with the remainder of the water. The fluid should be strained into the spray-machine, and kept stirred or agitated well during the spraying. A rather fine nozzle should be used.

At the end of a week, if the mites do not show evident signs of disappearing, a second spraying should be administered. It is suggested that on the first occasion all beds near the infected portion of the nursery should be treated.

Infection of nurseries usually occurs, probably, through mites that have strayed from neighbouring bushes or from weeds growing around the nursery. Where the presence of Scarlet Mite is detected in the neighbourhood, very young seedlings should be protected by dusting over plants and beds with flowers of sulphur.

Cutworm.—This insect is almost too well-known in both tea nur series and garden plots to need description. Suffice it to say that the blackish grub lives in the soil and gnaws through the stems of seedlings just below the soil level. Where plants are found damaged in this way, it is almost invariably through the agency of cutworm.

Where the seedlings are already in the process of growth, the use of leaf-baits provides a simple method for trapping the grubs. Cabbage and sweet potato leaves have proved successful in this connection.

A more satisfactory method of control is to rid the soil of cutworms before the plants have begun to show. This is done by means of a poison bait, which is placed out on the beds before the seeds are planted, or at least before the appearance of the shoots. The grubs are attracted to the bait, feed on it and are poisoned.

The following is a suggested recipe for the preparation of the bait:—

Copper arsenite	...	1 lb.
Bran	...	25 lbs.
Jaggery	...	3½ lbs.
2 or 3 oranges or limes		
Water	...	1 gall.

Dissolve the jaggery in the water (hot) and add the juice of the limes or oranges. Mix together thoroughly the bran and copper arsenite, and with the liquid work this up into a stiff mash. The bait should be either broadcast over the beds or placed in small heaps at intervals between the plants; it has not yet been ascertained whether one method has any advantage over the other. Copper arsenite is extremely poisonous, and on this account it must be used with caution, especially as far as fowls are concerned. This substance is obtainable from the Colombo Commercial Co., the present price being Re. 1-25 a lb.

Red Borer.—A pest of common occurrence in many parts of the tea area, but one which seldom attains to serious proportions, and is thus easily dealt with. It occasionally attacks seedlings. The borer itself is a reddish caterpillar about $1\frac{1}{2}$ inches long when full-grown, and its work is conducted in woody tissues. Thus only the older seedlings are attacked, at a stage when they are almost ready for planting out. The young caterpillar bores into one of the younger shoots, and tunnels down the centre of the main stem, which is frequently found hollowed out, even below the soil level. The fact that the boring is conducted in the centre of the stem (so that the main food-conducting tissues are not injured) allows the plant to continue to all appearances in a normal condition for some time. When the damage is first observed, the plants should be inspected daily for the presence of the borer, which is usually detected easily by the small heap of wood-pellets, cast out from the tunnel, lying at the foot of the plant. Another indication that the caterpillar is at work is the wilting and browning of the leaves on infested plants.

The only method of dealing with Red Borer in general use at present is to cut back the affected plants until the insect is reached; this is then destroyed. Alternatively, where (as in the case of seedlings or young plants in clearings, and occasionally in mature bushes), the main stem is tunnelled, and it may be inadvisable to cut it right back, a sharply-pointed piece of wire, inserted in the entrance hole of the borer, may be used for destroying the caterpillar inside the stem.

The most important thing in dealing with nursery pests is to report the attack when the plants first begin to look unhealthy, so that measures may be advised and applied at once, in order to give the plants a reasonable chance of escaping destruction.

As regards treatment, " prevention is better than cure " applies to all the pests quoted, even to some extent in the case of Red Borer, for the destruction of the caterpillar in each individual seedling prevents the formation of a moth which may ultimately carry infection to other plants. If cure must be applied, apply it early, and save many plants at the cost of few.

TEA TORTRIX.

As several people who are interested in tea are not acquainted with, or have no record of, the regulations which have been proclaimed against Tea Tortrix, they are reprinted here for reference.

The Plant Protection Ordinance requires that (1) the pest shall be proclaimed by His Excellency the Governor, (2) the measures which are to be adopted against it shall be published, and (3) the areas which are infested shall be declared.

As regards the measures to be adopted, it is to be noted that the Director of Agriculture may prescribe the manner in which plants attacked by a declared pest shall be treated, but any other regulations which are considered necessary must be made by His Excellency the Governor in Executive Council.

Tea Tortrix (*Homona coffearia* Niet.) was declared a pest by proclamation in Government Gazette of Nov. 11, 1927.

The regulations which have been published are—

(1) All egg masses, larvae, and pupae of Tea Tortrix on tea must be collected and destroyed within 24 hours of collection (Government Gazette, Nov. 18, 1927).

(2) Records of collections of Tea Tortrix egg masses, larvae, and pupae by weight or by number of leaves made on all estates over 10 acres in extent shall be sent to the Director of Agriculture at such intervals not exceeding three months as may be required by the Director of Agriculture (Government Gazette, Nov. 11, 1927).

A declaration of infested areas was published in Government Gazette, Nov. 18, 1927. The areas there enumerated are Chief Headmen's Divisions, but it may be taken that they cover all the tea area.

By the general provisions of the Ordinance, after a pest has been declared, it becomes the duty of the owner or occupier of an estate to report any occurrence of the pest on the estate to the Director of Agriculture. Failure to report is an offence, unless the owner or occupier had no reason to suspect the presence of the pest, in this case, Tea Tortrix. Presumably, if the appearances of the insect are discontinuous, each separate occurrence should be reported.

After an area has been declared infested, any plant pest inspector or sub-inspector may enter any estate in the area to determine whether the pest is present. It is to be noted that inspectors have had this power for many years, in the case of estates attacked by Shot-hole Borer.

T. PETCH.

THE ABSORPTION OF MOISTURE BY MADE TEA.

Deuss, J. J. B.—Over het wateraantrekkend vermogen van thee.—De Thee, September, 1926, pp. 97-101.

Deuss points out that during a rush of crop, or if the sifting room is too small, the made tea cannot be sifted in good time, and consequently may be left lying in a damp atmosphere for more than 24 hours. In that case, it will usually absorb moisture, and instead of a properly dried tea, with a moisture content of 6-8 per cent., it may contain so much water that its keeping qualities are impaired.

Further, cutting machines may give unsatisfactory results if the tea is not sufficiently dry. The performance of different types of cutters will differ, according to the degree of moisture in the tea.

Examinations of packet tea showed that 12 to 14 per cent. of moisture was not uncommon in them. As the tea when it came from the drier contained 4 to 6 per cent., evidently the remainder had been absorbed during sifting and packing.

As illustrating the absorptive capacity of tea, it is noted that cigars can be kept dry by storing them in tea in a stoppered bottle.

Experiments were carried out to determine how rapidly the absorption of moisture occurred, how strong the attraction of tea for water is, and what can be done to avoid it.

Teas of different types were used, both leaf teas and brokens, and from estates whose teas differed considerably in quality.

In addition to teas with a water content of about 8 per cent., samples were prepared from the former with approximately 0, 2, 4, 10-12 and 14-16 per cent. of moisture.

The different samples were then placed in closed tins or flasks, under the following conditions:—

(1) Over quicklime; relative humidity of the air about 0%
(2) Over 70% sulphuric acid; humidity of the air about 9%
(3) Over a saturated solution of calcium chloride; humidity of the air about 30%
(4) Over 43·5% sulphuric acid; humidity of the air about 50%
(5) Over water; humidity of the air about 100%

Further samples were exposed to the air of the laboratory, in which the humidity, measured by a self-registering hygrometer, varied between 70 and 80%, and on one occasion between 70 and 100%.

The gain or loss of weight was determined daily. The results obtained were the same whether leaf grades or brokens were used, and the source of the tea, whether from up-country or low-country estates, made no difference. It had been expected that the broken grades would absorb moisture the quicker, but that was not the case.

Over quicklime, all the teas lost moisture, tending to a minimum moisture content of about ½ per cent. The loss was greatest during the first two days. After twelve days the teas had deteriorated in quality, indicating that tea should not be dried too far, even at a low temperature. Deuss states that this has been previously observed in the case of tea stored in open packets over lime, and if tea kept in such a manner is to remain fit for consumption, the lime should be half slaked, so that the absorption of moisture is small.

With a humidity of 9% (over 70% sulphuric acid), the loss of water was less pronounced, but the process was similar to that with lime, the greatest loss occurring in the first two days.

In atmospheres of 30% and 50% humidity, all the teas, even those which contained only 4·7 per cent. of water, still lost moisture.

The teas kept in a saturated atmosphere (humidity about 100%) all absorbed moisture, even those which originally contained 14 to 16 per cent. of water. Within six days, the moisture content had increased, in some cases, up to 26·5 per cent.

In the atmosphere of the laboratory (humidity 70 to 80%), the teas which contained 14·8 to 15·8 per cent. of water lost moisture. Those containing 1 to 9·9 per cent. of water absorbed moisture from the air. As in the previous cases, the gain was greatest during the first two days. When the humidity of the atmosphere fell to 55 to 60%, all the teas began to lose moisture again, to re-absorb it when the humidity of the air again rose to 70 to 80%.

It follows that the more usual kind of tea, which has a moisture content of 4 to 8 per cent., will keep its moisture content fairly constant in an atmosphere of relative humidity 60 to 65%, so that the latter should be the relative humidity of a sifting room.

Teas with a very high moisture content rarely occur. These would be improved by exposure to a relative humidity of 60 to 65%.

Teas with a moisture content of 1 to 4 per cent. have been too severely dried.

Made tea usually has a moisture content of 4 to 6 per cent. It may be allowed to gain one or two per cent., but preferably not more. If sifting is finished in a day, the increase in an atmosphere of 70-80% humidity will be 1 to 1·5 per cent; that would not be serious, but if the sifting took two days or longer, or if the moisture which the tea takes up in cutting and packing is taken into account, the increase can amount to double that, and the moisture content of the tea would then be dangerously high.

To keep the sifting room dry, warm air from the driers should be drawn through it when it is not in use. If that cannot be done, a continuous steam of warm dry air should be led slowly through the room, so as not to disturb the fannings.

Teas kept in a saturated atmosphere had become musty and mouldy to a high degree in six to seven days. In an atmosphere of 70 to 80% humidity that occurred first after fourteen to sixteen days and then only to a slight extent.

Deuss arrives at the following conclusions:—

(1) If the relative humidity of the air is not above 60 to 65%, made tea should be sifted and stored within two days.

(2) If the relative humidity of the air is not higher than 70 to 80%, made tea should be sifted and stored within twenty-four hours.

(3) The sifting room should be as damp proof as possible and it should be capable of being dried by drawing in warm air. It is preferable to have a humidity of 60 to 65%.

(4) If the humidity in the sifting room is less than 55%, the tea loses moisture. It is not desirable to put on the market tea with too low a moisture content, since it is both bad for quality and uneconomic.

T. PETCH.

MEALY BUG

In De Bergcultures for December 24, 1927, Dr. H. Begemann gives an account of mealy bug on coffee in Java, which has recently become a serious pest. Three species cause damage to coffee, the worst being *Pseudococcus virgatus* Cock., known as the Lamtoro mealy bug. Lamtoro is the native name of the green manure plant, *Leucaena glauca*, and the insect develops on Leucaena and spreads from it to coffee.

The case is of interest to Ceylon tea planters in that *Pseudococcus virgatus* is one of the mealy bugs which attack our green manure tree, *Gliricidia maculata*. The latter is frequently severely attacked by mealy bug, especially in the districts which are subject to the rains of the north-east monsoon only.

Dr. Begemann states that Lamtoro (*Leucaena glauca*) and, to a lesser extent, Tephrosia and Calopogonium, are nurse plants of the Lamtoro mealy bug, and that there is no doubt that the Lamtoro favours the occurrence of the insect. In dry years especially it is clear that the mealy bug appears first on the Lamtoro and only subsequently passes over to the coffee.

To combat the mealy bug on its first host plant, the Lamtoro, Dr. Begemann recommends that the branches of the trees attacked should be flamed with a torch, and he states that that the trees do not appear to suffer too severely from this treatment.

T. PETCH.

WOUND GUM.

By

T. PETCH.

As considerable interest has been aroused during the last year by theories which have been based on the alleged occurrence of a wound-gum barrier in tea stems after pruning, it may serve a useful purpose, and prevent a too hasty acceptance of such theories, if we place before our readers some information concerning wound gum.

In many " broad leaf " trees and shrubs, when they are wounded down to the wood, the exposed wood becomes discoloured, usually brown, and this discoloration extends to varying depths into the wood. On microscopical examination it is found that the walls of the wood cells are impregnated with a brown colouring matter, and that the wood vessels, fibres, etc., are filled with a brown substance. In general, this brown substance is what is known as wound gum.

The name, wound gum, is in some respects an unfortunate one. The substance is not soluble in water and it does not swell when moistened. It is doubtful whether it should be considered a gum.

The term " broad leaf " trees has been used above, as a distinction from " needle-leaf " trees, such as pines and other conifers. In the latter, the substance which similarly fills the wood cells near the surface of a wound is a resin.

The formation of wound gum has been studied by many investigators, and it is now generally accepted that it is formed from the carbohydrates in the medullary rays and wood parenchyma. It is formed in living cells. Hence the cells on the surface of the wound, which have been dried out by exposure, do not take any part in the formation of wound gum. Partly for that reason, a wound gum " barrier," if present, is situated some little distance below the surface of the wound.

The formation of wound gum in plum trees begins a few hours after wounding.

Wound gum, by blocking the vessels of the wood, hinders or prevents loss of water from the exposed surface, and prevents the entrance of air and water into the naked wood. It is, however, incorrect to suppose that wound gum is produced for that purpose. The occurrence of " wound gum " is not restricted to the neighbourhood of wounds. The coloration of the heart wood of many trees, which is found as a normal phenomenon in perfectly sound stems and branches, is due to the deposition of " wound gum." Hence, wound gum is not necessarily associated with wounding nor with exposure of the wood to the air. The precise physiological reasons for the formation of wound gum have not yet been determined.

From the foregoing, it will be understood that even if a plant is forming wound gum, one must not expect to find exudations of gum, such as occur on Acacias or orange trees when injured or attacked by disease. Such exudations, as a rule, are true gums, and their mode of production is different from that of wound gum.

Wound gum cannot be identified by mere naked-eye inspection. Wood may be discoloured by other agencies, notably by fungi, either by the action of the fungus on the wood or by the presence of coloured mycelium in the wood cells. It is necessary to make a microscopical examination, before the presence of wound gum can be definitely determined. The investigations of the last fifty years have led to the introduction of numerous micro-chemical tests and stains for the identification of wound gum, and it is only by means of these that the presence of wound gum in a plant tissue can be established.

Interest in Ceylon in this subject of wound gum has been aroused by the application to tea of the results of investigations carried out in England on diseases of fruit trees, the most important of which, on the Silver-leaf disease of plum trees, have been conducted under the auspices of the Ministry of Agriculture by Mr. F. T. Brooks and his co-workers at Cambridge and elsewhere. When in England in 1925, I had the privilege of seeing Mr. Brooks' experiments at Cambridge, and his microscope preparations showing the effect of wound covers, the penetration of the fungus, etc.

Brooks and Moore found that the formation of wound gum in plum trees is most rapid in June, July, and August. It is not confined to those months, but apparently " gum barriers " are more readily formed in the summer months than at other times of the year. This finding is corroborated by the investigations of Swarbrick (Jour. Pomology and Horticultural Science, Vol. V., No. 2).

In the course of infection experiments with the fungus which causes Silver-Leaf of plum trees, Brooks and Moore found that it was almost impossible to obtain successful infections in June and July (and in one year in August), although infection followed inoculation quite readily in other months; and on seeking the reason for that they found that, where infection had failed, the fungus had penetrated to a depth of about half an inch, but further progress had been stopped by a barrier of wound gum. " The wood permeated by the mycelium was brown in colour as usual owing to the presence of gum in the cells, but, on the margin of the wood affected in this way, there was a narrow zone much more intensely discoloured, and , in fact, almost black. The vessels in this deeply discoloured zone contained even more gum than the region permeated by the mycelium, and the gum was darker in colour than in the latter. The mycelium had not entered this delimiting zone, so that the fungus was completely shut off from the healthy wood beyond. It seems certain that this 'gum barrier,' as it

may be called, definitely prevents the fungus from proceeding further.''

The foregoing is quoted from Brooks and Moore's paper, Silver-leaf disease—V., Journal of Pomology and Horticultural Science, Vol. V., No. 2, March, 1926, as is also the following extract.

'' The reasons for the rapid formation of a 'gum-barrier' in June, July and August, thereby preventing infection, are by no means clear. 'Gum barriers' are certainly not limited in time of formation to these months, because whenever there is failure to proceed with invasion after initial penetration, and in all cases of recovery from the disease, a 'gum-barrier' is responsible for the defeat of the fungus. There is reason to suppose, however, that 'gum barriers' are more readily formed in the summer months than at other times of the year. This is probably due to some special physiological condition of the twigs during these months. Alternatively, these barriers may be the more readily formed then because the fungus perhaps attacks most vigorously during that period. With the enhanced temperatures of the summer the fungus grows faster, although it may be argued that with higher temperatures the protective gum is also more easily formed. If it be true that the protective gum barriers are brought into being by the vigor of attack of the fungus, the ultimate escape from infection can be compared with the well-known case of resistance of certain varieties of wheat to *Puccinia glumarum*, where the ultimate immunity is due to a too vigorous initial attack by the fungus. The almost constant lack of infection during the summer months is, however, probably related to some peculiar feature in the initiation of attack of the fungus during the period, in association with the wound response of the host; otherwise one would expect that invasions by this fungus begun in April would stop in June: that is certainly not the case. It is the early stoppage of invasion in the summer months which is of peculiar interest in these experiments, but whether this is due primarily to the host or to the fungus, or whether the 'honours' are even between the two, for the present remains somewhat obscure, although the available evidence points to the physiological condition of the host as being most important.''

The practical deduction drawn by Brooks and Moore from the foregoing results is that, to escape infection by *Stereum purpureum*, the fungus of Silver-leaf disease, cutting out of dead wood and living branches of fruit trees should be done in the early summer.

But as regards wound covers, Brooks and Moore state '' *Wounds should, of course, be protected either with soft grafting wax or with one of the paints described in the earlier part of this paper* '' (italics mine,—T.P.).

It must be particularly borne in mind that these results refer to plum trees, in which the existence of a protective gum barrier (under certain conditions) has been proved, and to a particular parasitic

fungus, the cause of Silver-leaf disease. They cannot be transferred, without investigation, to tea, in which the existence of a gum barrier has not been demonstrated, and to the numerous saprophytic fungi which cause wood rot in tea.

Before these results can be applied to tea, it must be shown (1) that tea can form a similar gum barrier, and (2) that this barrier is effective in stopping the progress of all the saprophytic fungi which grow on tea wood.

Moreover, although Brooks and Moore were aware of the existence of the gum barrier in plum trees, and that it stopped the progress of the fungus which causes Silver-leaf, they nevertheless recommended that wounds on plum trees should be covered with grafting wax or a protective paint. But in Ceylon, the practical application of Brooks and Moore's results is diametrically opposed to what those investigators recommended, for in this country the advice which has been based on those results is that no protectives need be applied to wounds on tea.

In Ceylon there is a tendency to confuse wound gum formation with callus growth. These two are different processes, callus growth being the growth of new tissue from the cambium at the margin of the wound, while gum formation is the decomposition of reserve materials in the wood. Naturally, both depend, in the ultimate, on the presence of reserve food in the plant, but otherwise there is no relation between them. The presence of callus at the margin of the wound cannot be taken as evidence of the existence of a wound gum barrier below the exposed wood.

Nor can a marginal callus exert any protective function over the centre of the wound which is not covered by it. In the average tree, the external part of the woody cylinder, the sap wood, is less resistant than the central heart wood. Consequently, when a stem is cut across and the whole of its cross section exposed, the outer layers of the wood may be more readily attacked by fungi than the central part. (That is not universally true, as some fungi prefer the heart wood). The callus growth, which, as a rule, starts at the margin, covers first the less resistant sap wood and protects it from the direct attack of fungi, leaving exposed for a longer time (often permanently) the more resistant heart wood. The heart wood decays more slowly (in general) because it is harder and, in some cases, impregnated with gums, etc., not because it is surrounded by a ring of callus.

As regards tea, this idea of an immunity from decay conferred on the exposed wood by a marginal callus is even less applicable, as there is not the marked difference between heart wood and sap wood which occurs in deciduous trees.

As may readily be seen, when a cut stem dies back, the callus grows from the living part of the plant over the dead tissues, surrounding the dead stem with a socket of living wood and bark. The callus cannot grow through the dead stem along the surface of a gum barrier.

TEA AND SOIL ACIDITY.

Water Culture Experiments, II.

By

C. H. GADD, D. Sc. (Birm.).

The standard solution used for the water culture experiments described in the previous article (Tea Quarterly, Vol. 1, pp. 2-6) was made according to the following formula:—

Calcium nitrate	1·00 gm.
Potassium chloride	0·25 gm.
Magnesium sulphate	0·25 gm.
Potassium hydrogen phosphate	0·25 gm.
Ferric chloride	Trace
Water	1,000 c.c.

When freshly made this solution has a pH value of 5·1 (approx). The amounts (in c.c.) of N/10 sulphuric acid and N/10 sodium hydrate required to alter the pH of 1 litre of solution to any desired value are shown graphically in Fig. 1. It is apparent from this graph

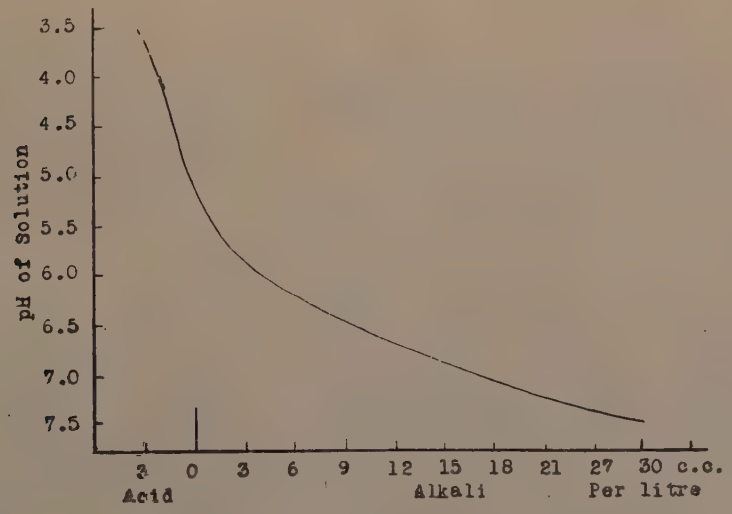

Fig. 1.—Titration curve of a standard water culture solution.

that equal quantities of alkali or acid do not bring about equal changes in the pH value of the solution. For example, about 3 c.c. of the alkali will change the reaction of a litre of this solution from pH 3·5 to pH 4·5, whereas 9 and 20 c.c. are required to change the pH value from 5·5 to 6·5 and 6·5 to 7·5 respectively. This is due to what is known as the " buffer action " of the solution. By buffer action is meant the resistance exhibited by a solution to change in pH through the addition or loss of acid or alkali; the substances which cause such resistance are termed " buffers." In this case, the buffer action is

due, at least in part, to the presence of potassium phosphate in the solution.

When sufficient alkali is added to the standard solution to raise the pH value to 7·5, a white precipitate is formed. The precipitate begins to form when the pH of the solution reaches 7·0 approx., and it increases in volume as the pH value rises, up to pH 7·5. When acid is added to the solution containing the precipitate the latter disappears when the pH value again reaches 7·0. The solution, therefore, contains substances which are soluble when the pH value is less than 7·0 and which become insoluble when the solution becomes alkaline.

It will be evident that the tea seedlings grown in the culture solution at pH 7·5 had less available food material than had the plants grown in more acid solutions, because part of the food supplies was rendered insoluble by the alkalinity of the solution. This fact, however, cannot vitiate the conclusions drawn from the experiment, because the results obtained when the seedlings were grown in the solution at pH 7·5 were not materially different from those obtained when the seedlings were grown at pH 6·5. In the latter solution the whole of the nutrient substances were available to the plants, in so far as they were in complete solution.

The deposition of a part of the nutrient substances (phosphates) from this culture solution as a result of an alteration of its hydrogen-ion concentration illustrates what is known to occur in the soil, and offers some explanation why plant growth is to some extent dependent upon soil acidity. It is well known that the ordinary methods of estimation show low values for " available phosphate " in soils rich in lime. Conversely, the action of an acid soil is to increase the available phosphate.

Soil reaction regulates the solubility of iron salts as well as of the phosphates. When certain plants are cultivated on calcareous soils they become chlorotic as a rule; the leaves assume a yellowish colour owing to defective development of chlorophyll. The reason for this has been found to be a lack of available iron, and chlorotic individuals have been cured by repeated doses of solutions of ferric salts. The chlorosis exhibited by the tea seedlings grown in the solutions approximating neutrality may, at least in part, be due to this cause.

During the course of the experiments, frequent corrections had to be made to all solutions, because changes occurred in their pH value as a result of the activities of the growing plants. The acid solutions tended to become more alkaline, while the solutions at pH 6·5 and 7·5 became more acid, until a pH value of 6·1 approx. was reached, when no further alteration occurred. In order to maintain the culture solutions at a constant pH value, they were tested at intervals of 3 or 4 days and corrected to their proper value by the addition of requisite amounts of alkali or acid.

In order to trace the movement of the pH value of the solution when tea seedlings were grown in it, a growing seedling was placed in a solution at pH 3·5 and another in a solution having a pH value of 7·5. In these cases the pH values of the solutions were tested at frequent intervals, but no acid or alkali was added to bring the pH values back to the starting points. When the solutions were changed, the new solutions were adjusted to the pH values at which the old solutions reacted when the change was made. The results of this experiment are shown graphically in Fig. 2.

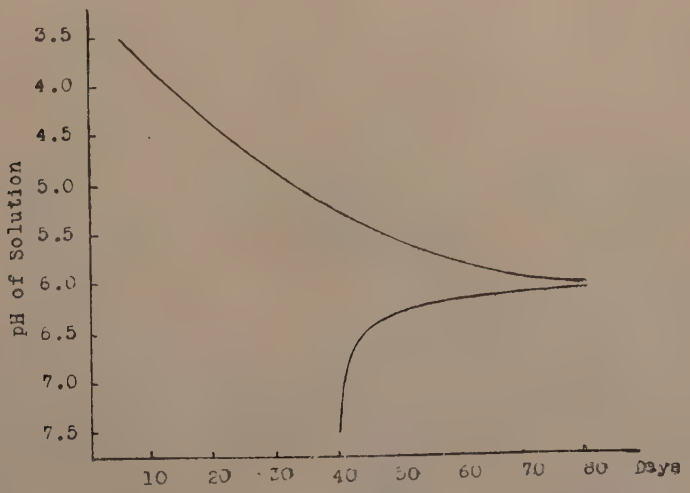

Fig. 2.—Graphs showing pH values of a culture solution in contact with living tea roots, when plotted against time.

It will be understood that Fig. 2 also represents the changes which were occurring in the culture solutions of the main experiment, except that the alterations were corrected at frequent intervals. It will be noticed that the solution at pH 7·5 altered very rapidly to 6·5 and therefore required more frequent attention than the others. The solutions at pH 5·5 and 6·5 became less and more acid respectively, until a pH value of 6·1 (approx.) was reached, while the more acid solutions gradually became less acid.

In the past, it has been incorrectly assumed that the pH value of the solution is altered to a value which meets the plant's requirements. It was apparent from the results of this experiment that 6·1 was *not* a pH value favourable for normal healthy growth of tea seedlings, and this value had nothing to do with the optimum requirements of tea.

It was suspected that the liberation of carbon dioxide by the roots was partly responsible for the alteration of the acidity of the solution. In order to test this hypothesis, carbon dioxide was bubbled through the culture solution after adjustment to pH 7·5. The precipitate present in this solution gradually dissolved, and the solution became clear,

indicating that the solution was becoming more acid. The lowest pH value obtained as a result of bubbling carbon dioxide through this solution was 5·2, and the solution remained at this value after standing in an open vessel for 24 hours. When, however, the solution was boiled in order to drive off the carbon dioxide from the solution the pH value increased to 6·0.

When carbon dioxide was bubbled through an acid culture solution (pH 3·8), no alteration occurred, even when the operation was continued for several hours.

It was evident, therefore, that although carbon dioxide had no effect on the pH value of the acid solution, it had a marked effect on the alkaline one. The rapid alteration of the pH value of the 7·5 culture solution, when tea seedlings were grown in it, was due primarily to the liberation of carbon dioxide from the roots. This experiment also suggests that the point of equilibrium (pH 6·1 approx.) reached in the experiments with growing plants is controlled by the carbon dioxide excreted by the roots, and not by the plant's requirements. The presence of carbon dioxide in the solution prevents the pH value from rising above 6·1.

Another culture solution was prepared, the formula of which was identical with that used in the above experiments, except that the calcium nitrate was replaced by an equal amount of ammonium nitrate. A third nutrient medium was made by adding 0·25 gms. of ammonium chloride per litre to the one containing ammonium nitrate. Both solutions had a pH value of 5·2. When tea seedlings were grown in these solutions, the solutions became more acid. This effect was directly opposite to that which occurred in the solution containing calcium nitrate. After one month, the solution containing ammonium nitrate had a pH value of 4·7, while the one containing ammonium chloride had reached a value of 3·7. After 2 months, the pH values were 3·6 and 3·3 respectively.

The change in reaction of a nutrient medium in contact with the roots of a living plant is dependent more upon the composition of the solution than upon the requirements of the plant. Solutions containing ammonium nitrate and ammonium chloride are physiologically acid, i.e., they tend to develop acidity when in contact with living roots, while solutions containing calcium nitrate are physiologically alkaline. It would appear from the investigations of other workers on this point, that, in general, ammonium salts are physiologically acid, while nitrates (except ammonium nitrate) tend to develop alkalinity.

These observations indicate that unintentional alterations in reaction may occur in soil as a result of manuring. Prolonged experiments at Rothamsted and elsewhere have shown that certain manures, e.g., ammonium sulphate, tend to increase the acidity of the soil, while

others tend to decrease it. In other words, the application of different manurial substances to the soil will cause changes similar to those seen to occur in culture solutions.

Coincident with the change in reaction of the culture solution, a corresponding but smaller change occurs in the acidity of the root sap. The following determinations of the acidity of the root sap of tea plants grown in culture solutions of fairly constant pH values were made at the end of the first period of the experiment.

pH of culture solution.	*pH of root sap.*
3·5	... 5·4
4·5	... 5·4
5·5	... 5·5
6 5	... 5·6
7·5	... 5·6—5·7

From these figures it is evident that marked differences in the pH of the solutions caused only small differences in the acidity of the root juices. This indicates that the plant possesses considerable power to regulate internal acidity. The importance to the plant of a constant hydrogen-ion concentration is not clearly understood, but it is probable that it is very necessary for the proper performance of the synthetic processes which take place within the plant. A marked alteration of the acidity of the plant juices is likely to affect adversely many of the vital processes essential to healthy growth.

The necessity for a suitable degree of acidity (hydrogen-ion concentration) of the medium surrounding the roots of a tea plant is demonstrated by these experiments. The pathological symptoms induced by an unsuitable reaction may be explained partly by the effect of the reaction on the solubility (and consequently their availability to the plant) of various nutrient substances, and partly by its direct effect upon the internal juices of the plant.

THE AIM OF FIELD EXPERIMENTS, I.

By

T. EDEN, M. Sc., A.I.C.

The Report of one of the District Planters' Associations, commenting on the preference for flat land urged in connection with the acquirement of an experimental estate for the Institute, concludes—"One would imagine moreover, that an average estate—fairly steep and rocky—such as 90% of those in Ceylon are, would provide more useful information than could be obtained from an ideal one." Since this view, which is apparently widespread, is based upon a misconception of the nature, scope, and limitations of field experiments, it is proposed in this and a later article to deal first with the nature of agricultural field experiments and their aim, and subsequently with the methods by which the undoubted difficulties can be overcome.

It will simplify the argument if the whole question is discussed in terms of a concrete example, and the manurial trial will be used for this purpose. Exactly the same reasoning would hold however if the experiment were concerned with pruning or some system of cultivation.

Now before a planter distributes over his land a considerable amount of more or less expensive manure he wishes to satisfy himself that a benefit is going to be derived from that application. In his mind's eye, he has to compare the yield and condition of the tea on his estate, or on a portion of it, with that which the *same piece of land* would produce in the absence of any manurial application. The phrase "the same piece of land" is in this connection of the utmost importance, because it lies at the root of all, or nearly all, of the differences of opinion between the experimenter and the practical man.

It will be obvious that the exact answer to the question is one which it is impossible to give, because it is not practicable to obtain a measure of yield on that chosen area of land under the two treatments, manured and unmanured, at one and the same time. It is of no use trying the plot unmanured one year or through one pruning cycle, and manured during a subsequent period, because although the actual plot of land is the same the seasons are proverbially unstable. What therefore one has gained in one direction has been lost in another.

The same sort of situation is created when two plots are used at the same time, one manured and the other untreated. This, however, is always the method one chooses, because it is the lesser of two evils and takes less time. As soon then as one embarks upon field experiments, one is inevitably putting one's hand to a procedure which will not give a direct answer to the question "how much benefit would this treatment give me on this piece of land." It can only give a close

approximation to the answer desired. The aim of field experimental method and the business of the experimenter is to make that approximation as close as possible.

The fact that must be realized at the outset is that field experiments are a compromise between what we want to know and what we can succeed in getting to know. It is just as impracticable to ask for what cannot be given, as it is to give something which is distantly removed from the conditions under which the practical man has to work. What then can the experimenter give in place of the ideal ?

He can give results which shall be as *comparable* as he knows how to make them. He must start by choosing experimental land which gives a reasonable hope that an apparent response to treatment is not due to the fact that the ground where he applied the manure was initially better than that which he has designated 'control,' and *vice versa*. That differences of a magnitude great enough to cause such results do exist, even in adjoining patches of land, is now largely recognized by experimenters. Every inadequate experiment which is added to the only too numerous collection of its forerunners accentuates the importance of the maxim that soil heterogeneity is one of the greatest of enemies. It is no remedy to increase or decrease the size of plots beyond a certain limit in the hope of levelling out soil differences, for by so doing other difficulties crop up which will be considered later.

The point has been made that the essence of an agricultural experiment is the provision of adequate comparisons. These should undoubtedly be made on the basis of as normal practice as is possible, but where normal practice fails to afford adequate comparison some slight modification must be made. Otherwise, no matter how practical and imposing the superstructure may look, the foundations are lacking. It must not be supposed that these modifications will be anything but small, and in considering them care must be exercised in deciding what are essentials and what are not. The loss of typicalness entailed by modifications requisite for experimental methods is small compared with the loss of accuracy and reliability to which the neglect of such methods would give rise.

This view, moreover, is not mere speculation, but the broad result of many years' intensive study of field experimental technique. More and more in recent years it has been realized that an agricultural experiment is not a thing to be laid down lightly and without thought, but demands careful consideration and a considerable amount of preliminary ground-work. For agricultural crops in temperate climates, this ground-work knowledge has been accumulating ever since Lawes started the classical experiments at Rothamsted in 1843; hence the comparative success of such trials. For tea it has still to be worked out.

It remains to apply these general considerations to the point in question, the type of land suitable for tea experiments, more parti-

cularly as outlined in the quoted extract at the beginning of this article. Comparability of plots of land suitable for experimental purposes depends very largely on two factors, drainage and soil depth. Unformity of either is unattainable on rocky land. Drainage is modified appreciably for some distance round large boulders and rocks; soil erosion is held up by boulders and rocks acting as terraces, and the accumulated soil results in the establishment of variable soil depths. In addition to these complications variable wind shelter is afforded to the tea by boulders. All these variable factors affect the crop to an unknown extent, and confuse the issue as to whether the manurial treatment is or is not solely responsible for any apparent benefit. The presence of a large rock in plots of the size which can be contemplated for experiments, would render those plots hopelessly incomparable with others not identically supplied. It may be suggested that if a number of such rocks were encountered in laying out an experiment, the small areas around them might be discarded. But the omission of such areas is surely a very cogent argument for choosing land in the first instance where these conditions do not occur.

One is very little better off with flat land in the sense in which such a description is interpreted in Ceylon. Really flat land is of course more uniform in soil depth and drainage than any other, but such land does not exist in the tea districts of Ceylon, judging by the writer's admittedly limited experience. What is commonly spoken of as flat land in Ceylon is land that has no very pronounced gradient and is usually made up of small undulations or knolls. The drainage in such cases runs in a number of directions; the soil varies in depth owing to the folds and pockets produced by the undulations, and moreover does not vary in an orderly fashion. The simple expedient of driving a walking stick into such ground gives a convincing proof of the variation of soil depth. Consequently such land is poor experimental land. It is erroneous to suppose, as would be inferred from a sentence preceding the extract already quoted, that the Tea Research Institute is seeking an estate where this 'flat' land preponderates.

What is urgently required is land uniform in slope over moderate sized areas. It is immaterial whether the slope is relatively great or small, provided that large rocks are absent. Such slopes, if they are gentle, are likely to have a reasonably uniform soil depth and their drainage will be constant too. If steep, then whilst the drainage and soil depth may change, they will change in a progressive manner, and not a haphazard one as is the case with boulder land and small folds. Such constant variation can be coped with in modernly-designed experiments. It is to this type of land that one looks to provide a suitable site for experiments, one, moreover, which will satisfy the legitimate requirements of the experimenter who aims at comparable plots, and the equally legitimate demands of the practical man for experiments that shall not be of academic interest only.

A NEMATODE ROOT DISEASE OF DADAPS.

By

C. H. GADD, D. Sc. (Birm.).

A nematode or eelworm has recently been found in association with a disease of dadaps (*Erythrina lithosperma* Bl.) in the Maskeliya and Dimbula districts, at an elevation above 4000 ft. The infected trees were being grown for shade and green manure for the tea through which they were interplanted. Difficulty has been experienced in establishing the dadaps in these fields, though in neighbouring fields and at higher elevations dadaps grow well.

Symptoms.—The diseased trees have a general sickly appearance. Numerous dead and dying branches are to be seen in the crown; the foliage is 'thin' and of a pale colour. (See plate 3, figs. 1 and 3). The 'thin' appearance of the crown is due to a premature fall of the lower leaves, the presence of dead branches, and the small size of the remaining leaves.

The leaves, before they fall, frequently become flecked with brown, particularly along the finer veins; this gives them a somewhat rusty appearance. The same discoloration may often be seen on old leaves of healthy trees just before they fall. This colour change appears to be part of the normal process which precedes defoliation, and should not be regarded as symptomatic of any particular disease.

A more characteristic symptom is the crowded state of the leaf-scars along the shoots of affected trees. Fig. 2 (Plate 3), is of a typical shoot. It will be observed that there are but few leaves at the apex, and that the scars left by fallen leaves occur at very short intervals along its length. The crowding of the leaf-scars is the result of imperfect elongation of the stem, and is a symptom of stunted growth.

At this stage, neither the leaves nor the shoot bear any lesions or spots indicative of a parasitic attack. The defoliation is from the base of the stem upwards, which is the opposite of what occurs in a true "die-back." Ultimately, the shoots are entirely defoliated; then they die. In severe cases, the trees may die.

The most characteristic symptom of this disease is to be found on the roots. Swellings or galls occur at various points on both large and small roots. These enlargements may be widely separated, or they may be so close together that the infected root appears to be abnormally thickened. They vary in size from scarcely noticeable swellings on the fine roots, to great knobs with irregular surfaces, two or more inches in diameter, on the older roots. (See figs. 1 and 2, plate 4).

The parasites which cause these swellings are small nematodes or eelworms, and they live within the root tissues. A root gall, if carefully dissected or broken open, may show the female nematodes as glistening white sacs, or pearly white, rounded, pear-shaped bodies about half the size of a pin's head, just large enough to be seen with the naked eye.

The nematode belongs to the species *Heterodera radicicola*. Owing to the characteristic galls produced by this parasite, the disease on other plants is known by such common names as " root knot," " root gall," "eelworm disease," etc. Similar names might be applied to this disease of the dadap.

The root galls should not be confused with the nodules caused by nitrogen-fixing bacteria. The nitrogenous nodules of the dadap are almost spherical in shape, and vary in size up to half-inch or more in diameter. They are attached to the sides of the rootlets from which they may easily be broken off. The characteristic galls of this disease are enlargements of the roots themselves; consequently they cannot easily be detached. The difference in appearance between the injurious root galls and the beneficial bacterial nodules may be seen by comparing figs. 1 and 3 of plate 4.

Godfrey (3) gives the following description of the general effect of *Heterodera radicicola* on attacked plants. " As a rule, root-knot produces no malformations or enlargements on the parts of the plant above ground and consequently is frequently overlooked. However, plants badly infested are dwarfed, wilt readily in hot, dry weather, and are usually a paler green than healthy ones. Where this attack is most severe, plants may be entirely killed. In the case of a mild attack, only a small amount of dwarfing, together with a reduction in yield below the normal, is noticeable. Sometimes even the dwarfing is absent and the reduction of yield is not noticed. Since the disease is widely prevalent in some districts, the reduced yield is supposed by growers to be a normal one." The poor growth of the infected dadaps, the dwarfing and pale colour of the leaves, the imperfect elongation of the stem as shown by the crowding of the leaf scars, and the presence of root galls are symptoms which conform with those known to occur on other plants seriously attacked by this parasite.

Attacks by this parasite result directly in an interference with the normal functions of the root system arising from the malformation and the premature death of infected roots. The debility, so induced, renders the plants more liable to attack by other parasites, especially root fungi, which may assist in causing the death of the attacked plants. No other parasite or root disease fungus was found on the dadap trees examined; so it must be concluded that the parasite, *Heterodera radicicola*, is the primary cause of the diseased condition described here.

Figs. 1 and 3, Dadap trees infected by *Heterodera radicicola.* Fig. 2, Shoot of infected tree, × ¾.

PLATE III.

The parasite.—Nematodes are worms of relatively simple structure. Typically they are transparent, slender, eel-like organisms which move about by a peculiar whipping process. Owing to their narrow cylindrical shape they have received the popular names of "eelworm" and "threadworm."

In the earlier stages of its development, *Heterodera radicicola* has the typical eelworm shape, but, later, the females become much swollen and pear-shaped. The females may usually be found in abundance within the root-knots or galls. When mature, she is pearly white in colour and measures from 400 to 1000 microns (1/60 to 1/25 inch) in length. As the development of the ovaries proceeds, the female is reduced to a lifeless bag of eggs.

The female produces as many as 500 eggs, which measure about 90 microns (i.e., less than 1/250 inch) in length. The eggs are laid within the root galls and hatch *in situ*, or in the soil if they are liberated by the death or decay of the galls. The larvae which emerge are colourless, very minute, too small to be visible to the naked eye, slender and eel-like. They may migrate within the root tissues or may escape into the soil, where they may survive for months without parasitic relations (4). They move actively through suitable soils, and on reaching a favourable root, preferably a young feeding root, they force their way in, usually near the tip. The entry of larvae into the root stimulates the root tissues to abnormal activities, which result in the formation of the characteristic galls.

The larvae develop and become sexually mature while in the root. The male is similar to the larva in form and appearance but is much larger. He measures about 1·4 mm. in length (rather less than 1/16 inch), but is not over one-fortieth as thick as he is long. After fertilizing the female, he bores his way out of the root into the soil and soon dies. Consequently, he is rarely seen except when searched for just at the right time.

The entire life cycle is completed in about 30 days. In warm climates the nematodes may pass through 10 to 12 generations in a year, but in cooler climates the number is less.

Duruz (1) has determined that the optimum temperature for Heterodera is between 65° and 85°F. Generally speaking, temperatures above 65°F. increase its activity, and temperatures below 65°F. and above 85°F. decrease its activity. The nematodes may be killed by freezing and by heating to 101°F.; by the latter treatment the larvae and eggs are also killed. In parts of Florida certain susceptible garden crops can be grown in infested soils during the autumn, winter and spring, owing to the greatly reduced activity of the nematodes at temperatures below 55°F. In the tropics, however, the soil temperature is such as will favour the activity of the parasite.

Heterodera appears to prefer light and sandy soils. Root-knot is seldom found in heavy soils, possibly because the nematode finds it difficult to make its way from one root to another through such soils, and possibly because clay soils readily retain sufficient moisture to interfere with the proper aeration of the parasite.

Fawcett (2) has recorded that although *Heterodera radicicola* is often found on coffee in Porto Rico, there is no real evidence that the trees are really injured by this disease. He suggests that the heavy nature of most Porto Rican coffee soils prevents it from becoming the pest which it sometimes is elsewhere.

Occurrence.—Heterodera radicicola is already known as a parasite of over 500 species of wild and cultivated plants in different parts of the world. On some of these, the nematodes appear to inflict no visible injury except the formation of small knots on a few of their smaller roots. Other plants, though more seriously infested as shown by the abundance of galls on the roots, exhibit no apparent injuries or reduction of crop. There is a third class, however, in which the nematode injury is very severe, and which cannot be grown profitably in infected soil.

In Ceylon, Heterodera is well known as a destructive parasite of tea seedlings. Nurseries have been partially or wholly destroyed by its ravages. A photograph illustrating the damage caused by this parasite in a tea nursery was reproduced in the first number of this Journal (Feb., 1928). The same nematode has also been recorded in isolated cases as a parasite of mature tea bushes. As yet, its occurrence on mature tea is relatively rare, but the fact that this eelworm has been known to attack well-grown bushes and cause injuries sufficiently great to be noticed by the practical planter suggests that the propagation of this parasite on the roots of plants intergrown with tea may ultimately prove to be a menace to the tea itself. This possibility requires consideration.

The same parasite has been found within galls on the roots of otherwise apparently healthy dadaps. At present, very little is known concerning the distribution of this nematode in tea soils in Ceylon, and the discovery of it in roots of what appear to be normal healthy dadaps is disconcerting. The extent to which tea soils are infected, and the frequency of occurrence of nematode galls on the roots of vigorously growing dadaps have yet to be ascertained.

Treatment.—Satisfactory control of Heterodera is obtainable only where the soil can be sterilized by heat. Steam sterilization has been proved to be most efficient, but such treatment can be applied economically only on small plots and seed beds. The sterilization of large areas of tea soils by steam or hot water is impracticable. Moreover, such treatment can, of course, only be applied to soils which do not bear any living plants.

PLATE IV.

Fig. 1, Nematode galls on small dadap roots, x ½. Fig. 2, Old galls caused by *Heterodera radicicola,* x ¾. Fig. 3, Nodules on dadap roots caused by nitrogen-fixing bacteria, x ½.

Control by chemical agents has not proved feasible on any adequate scale. McClintock (5) has shown that the nematode could not be combated satisfactorily by any of the following:—carbon bisulphide, corrosive sublimate, calcium carbide, ammonium sulphate, formalin, nicotine, benzine, or kerosene. Stone and Smith (7) demonstrated that manganese sulphate, common salt, potassium nitrate, magnesium sulphate, calcium sulphate, kainit, sodium nitrate, and lime are ineffective. Concerning the value of lime, Nowell (6) says " The usefulness of lime in this connection is disputed, but in any case only heavy applications can be expected to have any notable effect." Duruz (1) obtained almost perfect control by treating the soil with 200 lb. of sodium cyanide per acre, followed by a second similar treatment 5 days later. For this treatment, however, the soil must be free from growing plants.

The cure of plants that are already infected is practically impossible. It is difficult to conceive of more than palliative effects resulting from any chemical or other treatment of an organism so well protected, during much of its life history, by the tissues of its host.

A method sometimes applied with good results to permanent crops, like the peach, is that of forcing the trees to grow in spite of the presence of the parasite. Commercial peach growers cultivate thoroughly and apply an abundance of fertilizer, particularly stable manures and commercial nitrogenous fertilizers, rich also in potash, so that the roots are made to grow faster than the nematodes can produce knots. Some such method would be worth trial if dadaps were a main crop in Ceylon. But as the dadap is grown as a shade tree and to provide green manure, as mulch or loppings, for tea, the practice of such forcing methods does not appear justifiable.

The most satisfactory method of combating the root gall disease is that in which infested fields can be planted with non-susceptible crops for a period of years. If the ground could be kept absolutely free from vegetation of all kinds, which for obvious reasons is impracticable, the parasite could be starved out in a few years. Similar results may be obtained by growing non-susceptible plants for three or more years.

The problem of a satisfactory treatment of this disease on dadaps is complicated by the presence of the tea, which is the main crop. The health and the vitality of the tea are of more importance than the presence or absence of a particular variety of shade tree. For this reason, the question of immunity or susceptibility of tea to this parasite becomes of primary importance.

In the seedling stage, tea is known to be very susceptible to this disease, but so far, Heterodera has not shown itself to be a serious pest of old bushes. Its occasional occurrence on mature bushes indicates clearly that the roots are not completely immune from attack. Consequently it appears advisable to take every precaution against the

propagation of the parasite on the roots of other plants intergrown with the tea. It might be argued that the presence of plants more susceptible than tea is a safeguard for the tea, insomuch as the parasites will attack the more susceptible roots in preference to the tea roots. That would be true if the attacked roots were removed from the soil and destroyed. Otherwise they merely form breeding grounds for the parasite.

The only practicable way of dealing with the problem in areas where the dadaps are seriously infected, where they make poor growth and provide little foliage for shade or green manure, either as mulch or as loppings—in short, where the dadaps do not efficiently serve the purpose for which they are grown—is by the complete removal of the dadaps and the complete destruction of their roots. As already explained, the prospect of the discovery of an efficient cure is very remote. It may be possible to improve the condition of the dadaps by "forcing" methods, at considerable labour and expense. If such methods include the use of heavy doses of lime, as might be expected, the effect of the treatment on the adjoining tea will have to be considered. It would appear to be a more economical proposition to abandon the cultivation of dadaps on such areas, and to grow other shade trees in their stead.

Where, on examination of the roots, dadaps are found to be infected, though otherwise they appear normal and healthy, no action should be taken at present, other than close observation to ascertain whether the trees are deteriorating. Until more is known concerning the distribution of this parasite in tea soils and its occurrence on dadap roots, it is impossible to state whether the presence of root galls is to be interpreted as the beginning of an attack, or that dadaps, grown under more or less ideal conditions, are tolerant of the parasite and sustain little damage from its attacks.

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WEEVILS INJURIOUS TO TEA.

By

S. STUART LIGHT, A.R.C.S., D.I.C.

A case was recently investigated by the writer, in which weevils were reported as damaging two-year-old tea stumps in a clearing of some 15 acres on the top of a ridge 5600 ft. high.

At the time of report, large numbers of the weevils had already been collected by hand, but even so it was found, on examination shortly afterwards, that every plant bore from two to four or even more weevils. In this instance, prompt measures were applied, and the advent of several rainy days served to disperse the insects without much loss to the plants. A number of the latter, however, suffered much defoliation before the pest was controlled. In a case such as this, the insects feed mainly on the buds and young shoots, so that, if abundant, and allowed to continue unchecked, it is possible that considerable damage to the plants attacked may ensue.

The infested area was bordered by low jungle, but although search was made, no trace of the weevils was found on jungle plants. It is not certain, therefore, whether infection occurred from the neighbouring jungle, or whether the weevils, possessing wings, arrived from a more distant region.

Fig. 3. Lower, *Astycus apicatus.* Upper, *Astycus immunis.* x 1½.

Two species of weevils were concerned in this instance, *Astycus apicatus* Mshll. and *A. immunis* Walk. Weevils are minor pests of tea in Ceylon, and very few records of outbreaks exist. According to the Government Entomologist, who has kindly furnished me with information from the Department of Agriculture records, only six reports of Astycus spp. have been received during the last twenty years. Attacks are usually confined to foliage in an early stage of growth; thus tea stumps, seedlings, and bushes newly pruned have all been recorded as suffering from weevil damage. At the same time,

species of Astycus occasionally attack the younger growth on mature bushes, and one species of a different genus appears to prefer the older leaves.

Brachyaspisthes (*Brachyaspistes*) *tibialis* Jek. was the name recorded for a species seen by Green in 1899 attacking young tea plants, but it has since been ascertained that this species is identical with *Astycus immunis*. The plants in question were three months from pruning, and Green described the weevils as devouring all the new shoots, leaving the stumps bare of foliage.

Astycus lateralis F., a recorded pest in Ceylon, has also been described as attacking tea in India. In 1897 it was reported on an Indian estate, where it " was said to come by night in thousands and simply strip the bushes " (Watt and Mann, 1903).

A larger species, *A. chrysochlorus* Wied., known as the Green Beetle, has been said to strip the young leaves from tea shoots in India.

At least one other species has been recorded as a pest of tea in Ceylon. *Myllocerus curvicornis* F., a well-known pest of green manures, also occasionally turns its attention to tea, but from the few records that exist it is evident that little damage is caused, the insect apparently preferring the older leaves of the bush.

As regards the alternative food plants of these weevils in Ceylon, little information is available, and it is probable that the recorded list is far from complete. *Astycus immunis* has been recorded on Acacia, and a variety, *A. immunis* var. *bilineatus* Mshll., has recently been observed by the writer attacking dadap (*Erythrina lithosperma*). *A. lateralis* is a pest of teak (*Tectona grandis*) in India, and *A. chrysochlorus* has been reported there on rubber (*Hevea brasiliensis*) and *Pithecolobium Saman*. Astycus spp. have been recorded on jak (*Artocarpus integrifolia* L.), (*Ficus Carica* L.) and rose (*Rosa indica* L.). *Myllocerus curvicornis* is a notable pest of dadap, and has also been seen to feed on Albizzia, Acacia, *Gliricidia maculata* and cacao.

A brief description of the Ceylon species follows. In each case the general colouring of the body is derived from the scales that cover it. In all the species, considerable variation in size occurs, while the male weevil is smaller and slighter than the female.

Astycus apicatus Mshll. Uniform grey colouring, usually with a bluish tinge; average length $7\frac{1}{2}$-9 mm.

Astycus lateralis F. Pale metallic green; average length 8-10 mm.

Astycus immunis Walk. Colour varying greatly, from bronze-yellow to bright metallic green. Smaller than the preceding; average length 6-7 mm.

A. immunis var. *bilineatus* Mshll. Bright metallic green, with a lighter green stripe on each elytron.

Myllocerus curvicornis F. Greyish-white, with grey flecks on the elytra. Average length 7-8 mm.

One of the chief requirements for the control of an insect pest is usually a more or less complete knowledge of its life-history. Unfortunately, little is known regarding the life-histories of the weevils which attack tea. Bred in captivity by the writer, eggs have been laid freely, and the larvae have hatched out, but owing, apparently, to their inability to find suitable food, they have never developed beyond the first instar.

In the case mentioned at the beginning of this article, where *Astycus apicatus* and *A. immunis* were taken on the same plants, the two species were bred up together, and the eggs, which were oval and yellowish white, were laid in clusters either on the surface of the soil or in the soil itself. The tiny, yellow, legless larvae, on hatching out, at once worked their way into the soil, and wandered through it evidently in search of food. Experiments were carried out with the object of discovering their natural food, but none of the substances submitted, which included tea rootlets and portions of older roots, were touched by the larvae. From these observations, it is probable that the eggs are laid normally in the soil, and the larvae live in the same medium; the latter evidently feed little, if at all, on the roots of tea, but probably on the roots of other plants, as yet unknown.

The only methods of control, therefore, that suggest themselves at the present stage are the collection of the weevils, and the application to the plants of some substance poisonous to the insects. Hand-collection may be of decided value, if applied early, as shown by the writer's experience. As regards a "stomach-poison" for the weevils, copper arsenite mixed with three times the quantity of powdered slaked lime should be dusted over the plants after a preliminary spraying with water: this treatment is advisable only on young plants or bushes just coming out of pruning. Care must be exercised in the use of copper arsenite, owing to its highly poisonous nature.

NEW IDEAS IN FACTORY PRACTICE.

In recent numbers of De Bergcultures, Dr. J. J. B. Deuss, of the Proefstation voor Thee, has described various new devices in tea machinery or factory construction. As these may be of interest to our readers, we give the following summary of the information and descriptions.

In De Bergcultures, No. 26, Dr. Deuss deals with the question of pneumatic sorting, i.e., the separation of bulk tea into grades by means of a current of air. This is the principle by which good corn, light corn, and chaff are separated in a threshing machine,—the principle of the winnowing machine. The idea of sorting tea by this method is becoming of interest in Java, where several estates already make use of it.

As Dr. Deuss points out, the idea of using a winnowing machine for grading tea is not new. Jacobson, in his hand-book of tea preparation (1848) gave an illustration and description of such a machine, and similar machines were to be seen in use in Java in the early years of this century. The first power-driven winnow, however, was Kerkhoven's Panoembangan winnower.

As is well known, dust and fannings can be cleaned by allowing them to fall opposite a fan so that a current of air passes transversely through the tea. This operation came to be done in a rectangular wooden box or pipe, and by lengthening the pipe and using larger and more rapid fans, the present form of winnowing machine has been arrived at. Not only the finer grades, but all other sorts can now be separated by this means.

The Sindangsari winnowing machine is a rectangular wooden chest, about 39 feet long, $7\frac{1}{2}$ feet high, and $5\frac{1}{2}$ feet broad. The fan, situated at one end, has a diameter less than $5\frac{1}{2}$ feet. At the other end, the inlet, is a set of three slats (Venetians) placed horizontally. The machine is furnished with a feeder above, and bins to receive the various grades stand beneath.

The Ganoeng Mas winnowing machine is about 17 ft. high and $30\frac{1}{2}$ ft. long. It is furnished at one end with a fan, the speed of which can be regulated to 600, 400, or 200 revolutions per minute. The machine separates the tea into twelve grades and has a capacity of 500 pounds of dry tea per hour. With this machine, there has been obtained on Ganoeng Mas a saving in sorting coolies equivalent to about 15 women per 1000 pounds of tea. Light and red leaf are particularly well removed.

In other cases, the winnowing machine is tubular, about 22 ft. long, furnished with bins beneath, and with inspection windows along one side.

On Leuwimanggoe, the bulk tea is passed through a winnowing machine, about 26 ft. long, furnished with a Blackman's fan working at 450 revolutions, and is separated into ten grades. The cut and sifted tea goes through a second winnowing machine. The machine is fed through an opening 2 cm. wide, and deals with 250 pounds of tea in 9 minutes. All red leaf is completely removed.

Another form of winnowing machine, though working on the same principle, is of a totally different pattern. The unit is a vertical tube, furnished at a certain height with a side tube and hopper through which the tea is introduced. The tube stands on a box, and terminates above in another box, on which is fixed an extracting fan. Air is admitted through the lower box, while in the tube is a valve by which the suction in the tube may be regulated. By this apparatus, the tea which is introduced into the tube is divided into two grades, the lighter tea ascending to the upper box, while the heavier tea falls into the lower. The idea is that with several of these units arranged in series it will be possible to obtain a separation into as many grades as desired.

The advantages of pneumatic sorting are stated by Deuss to be as follows:—

(1) Saving in sorting coolies.
(2) Saving of time.
(3) Saving in hand sieves, winnows ,and sifting machines.
(4) The tea is not greyed in the process and does not lose tip.
(5) Dust and fibre are removed extremely well, better than in previous processes, and the teas have a much better appearance.
(6) All light undesirable leaf is taken out of the good grades.
(7) Sorting is done more quickly and consequently the tea absorbs less moisture.
(8) With a constant wither, constant grades are more easily obtained.
(9) Although stalks are not removed by winnowing, these are concentrated in one or two grades in the machine, and they can thus be the more easily picked out. It is permitted to hope that by further improvements it will be possible to winnow out the stalks.

In De Bergcultures, No. 29, Dr. Deuss gives hints on humidifiers or spray diffusers. These are now in use in several factories in Java for the purposing of maintaining a humid atmosphere in the fermenting room. He objects to the term " fog or mist plant " as misleading, and suggests that it has been invented to cover defects in the apparatus.

The essential requirements of a humidifier are enumerated by Deuss as follows:—

(1) It should be capable of raising the humidity of the fermenting room to 90-95%, without the formation of any fog or mist, except for, at most, a short distance from the orifice of the humidifier.

(2) The humidity should remain constant, whether the doors of of the room are open or closed.

(3) It should be possible to maintain the humidity constant, whether the temperature rises or falls, by regulating the whole apparatus by means of one tap.

(4) The working must be so simple that no specialist is required for regulating the apparatus.

In De Bergcultures, No. 28, Dr. Deuss describes a method of construction of a withering loft, devised by Mr. E. de Wit, by which the direction of the air current over the leaf can be reversed at will. As is generally recognized, the leaf which is nearest the air inlet withers the quickest, while that nearest the fans withers more slowly because the air has taken up moisture in its passage along the loft and has therefore a higher degree of humidity. Consequently, when the leaf at one end of the loft is properly withered, that at the other end is still under-withered.

As it is not practicable to interchange the leaf on the racks, the obvious method of securing an even wither is to reverse the air current through the loft. That is done by the following arrangement.

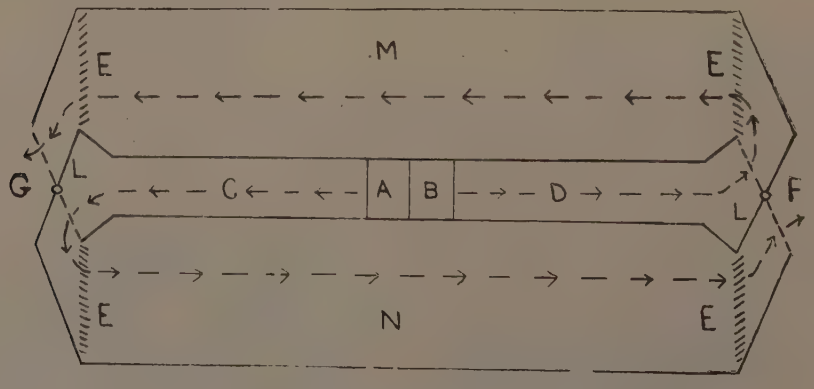

Fig. 4. Modified from De Bergcultures.

The loft is divided by partitions extending from floor to ceiling into two withering chambers, M and N, and a central passage CD. The racks are omitted in the figure. A and B are the air shaft, divided into two by a door in the middle of the passage. At each end of the withering chambers, a partition E is fitted with vertical shutters

to ensure distribution of the dry air and to regulate the direction of the air current. Fans are situated at F and G. L and L are shutters or doors working on a central pivot and capable of being turned from the position shown to that indicated by the dotted line through the pivot.

With the shutters in the positions shown by the solid lines, fan F draws the air from passage C through chamber N from left to right, while fan G draws air from passage D through chamber M from right to left, as shown by the arrows.

If, however, the shutters are turned into the positions shown by the dotted lines, fan F draws air from passage C through chamber M from left to right, while fan G draws air from passage D through chamber N from right to left.

Thus by altering the position of the shutters or doors, L and L, the direction of the current in each chamber is reversed.

The passages C and D serve as mixing chambers for the air.

T. PETCH.

THE TECHNOLOGY OF TEA.

NEUVILLE, H.—Technologie du Thé. Composition Chimique de la Feuille. Récolte et Manipulation. Procédés Européens. Procédés Asiatiques.—Seconde edition: revisée avec le concours de la Station expérimentale d'etudes sur le Thé de Buitenzorg (Java). Paris, 1926. Pp. 304, + 28 plates.

The technology of tea has made considerable progress during the last twenty years, and numerous researches have been carried out on manufacture, but the accounts of these researches and the modifications in manufacture are disseminated through a large number of journals. The object of the author has been to collect the data thus obtainable concerning the chemistry and manufacture of tea, and to present this in as simple a way as possible so as to make it of universal interest. The result has been an eminently readable account of the facts concerning the chemistry of the leaf, withering, rolling and all the processes involved in the art of tea-making, together with a description of the machinery employed, supplemented by excellent photographs and several plans. As was to be expected the author cites the results of the Java workers to a great extent, and it is not quite certain to what extent it is desirable to generalize on all the points made.

The first part deals with the structure and composition of the tea leaf, and includes a review of the methods of analysis. The principal constituents in tea are given as tannin, caffeine, glucoside and essential oil, while protein and other substances like theophylline,

xanthine and carbohydrates are mentioned. Although tannin plays such an important part in tea it is surprising how little is definitely known about this group of chemical substances and their decomposition products. Tea tannin appears to correspond to a formula C20 H20 O9, containing one ketone and eight hydroxyl groups in the moelecule, and it is placed in the group of oak tannins on account of the formation of red compounds (phlobaphenes) when boiled with acids. It readily undergoes oxidation with the formation of red and brown insoluble products, which are however soluble in an aqueous solution of tea tannin, and these substances are supposed to account for the colour of tea.

The manufacture should not be conducted in an empirical fashion, but should be controlled by the use of thermometers and hygrometers; and in the case of withering, the degree of wither should be determined by actually weighing leaf samples, while records of temperature and humidity should be kept for reference.

The wither should not be too rapid, 12 hours being regarded as a minimum while 18 hours is considered the best period. High temperatures are to be avoided, and if hot air is used it should be well mixed with fresh outside air, while the lofts should be as open as possible during the day to admit fresh air and to get rid of any stale aroma. It is advised that the fine leaf be withered apart from the coarse leaf as far as possible, owing to the tendency of the fine leaf to dry out too rapidly. It is important to wither the leaf so that the concentration of the sap is nearly the same each day. The loss of weight on withering will therefore depend on the moisture content of the leaf.

The essential part of the rolling is to bruise the cells of the leaf and to allow blending of the contents so that the several substances in the cell sap can react with each other, while some of the juice is squeezed on to the outside of the leaf. The reactions concerned, however, can proceed within the leaf itself. At the same time the leaf is given a twist, and undoubtedly fermentation also proceeds during the rolling, which must be carried out with great care. The roller should be filled in small quantities at a time, the pressure applied gradually and the cover eased periodically to keep down the temperature inside the roller.

Fermentation, which proceeds best at a temperature of 20-25°C., is very slow at low temperatures, but temperatures above 30°C. are unfavourable to the fermentation as the aroma becomes less agreeable, and a portion of the soluble fermentation products are rendered insoluble. During the process the tannin undergoes considerable changes, with the formation of bodies which give strength and body to the infusion, while the essential oil is developed. Air is necessary for the spontaneous chemical transformations which take place during

fermentation, but drying of the leaf during the process should be prevented by maintaining an almost saturated atmosphere in the fermenting room. The temperature of the atmosphere, the humidity, the quality and moisture content of the leaf, together with the locality and time of the year, are factors which contribute to the duration of the fermentation, so that the actual time required is determined by experience gained in judging the colour and aroma of the leaf. The presence of an enzyme system consisting of oxidase and peroxydase has been definitely demonstrated in tea leaf, and these enzymes play an important part in the fermentation, contrary to the idea that microbes normally take part in the process.

The essential rôle of drying is to arrest the fermentation, but a few modifications occur depending on the temperature employed, which should be regulated by means of control thermometers. High temperature desiccation is attended with loss of quality, and prolonged drying renders some of the constituents insoluble.

The last section deals with the preparation of tea in China, Formosa and Japan, together with a classification of these teas, and ends with a useful bibliography of the literature relating to the chemistry and technology of tea. The volume is a distinctly needed and useful compendium for those interested in the subject, and the author is to be congratulated on the readable, if not very orderly, account of the great mass of work in the many fields involved.

D. I. EVANS.

ENQUIRY.

We have received a request from Java for seed of a small-leaved hybrid jat of tea which does *not* flower abundantly.

We shall be pleased to hear from any one who can supply this, and to put them in communication with the applicant.

T. PETCH.

THE PARASITISM OF ROSELLINIA ARCUATA.

By

C. H. GADD, D. Sc.

Rosellinia arcuata, though by no means the most common of tea root disease fungi, is probably the best known by name to tea planters in Ceylon. In a short account of his first experience of this fungus, Petch has described (*Tea Quarterly*, Vol. 1, p. 14) how the individual plants of a Panax hedge died in regular succession, as the fungus reached and enveloped their stems at ground level.

Its action in tea is similar, except that instead of travelling along a straight line, it usually spreads outwards along the radii of a circle, and kills the tea bushes in its path. Thus, unless the fungus is checked, an area attacked by Rosellinia becomes larger annually. The dead and dying bushes—the latter are on the perimeter of the area—bear a copious black fungus growth which is the vegetative body of the fungus *Rosellinia arcuata*.

Moreover, it is not weakly bushes only which die when attacked by this fungus; vigorous, healthy bushes also succumb. The finest tea bushes are as susceptible to attack by Rosellinia as the weaklings. Even the magnificent specimens sometimes spoken of as " show " bushes are not immune.

The rate of progress of the fungus and the speed at which the fungus will kill a tea bush are doubtlessly influenced by external environmental conditions. The constant association of a specific fungus with a definite diseased condition, its presence on dead and dying bushes, and the fact that death follows the invasion of the fungus, no matter how vigorous the bush is before the arrival of the fungus, can mean only one thing, namely, that the fungus is the primary and sole cause of the death of the bush.

The accuracy of this conclusion has recently been questioned because experimental proof has not been produced in support, and another theory has been advanced to explain the observed facts. Whatever may be said in its favour, however, the new theory suffers from a similar disadvantage, viz., it is unsupported by experimental proofs, though many attempts have been made to obtain them.

What constitutes proof of the parasitism of any specific organism ? The rules of proof were formulated by Koch, and have been appropriately termed the Canons of Koch. They may be expressed as follows (Duggar, *Fungus Diseases of Plants*, pp. 76-77) :—

(a) Under diverse conditions the fungus must be constantly and abundantly associated with the disease, or pathological state.

(b) The organism should be grown in pure cultures, when possible, and its differential characteristics well studied.

(c) The characteristic disease should be produced by infection experiments with a pure culture.

(d) The fungus associated with the disease induced should be identified as the one originally separated, and any abnormalities of host should likewise correspond.

It will be noted that rule (a) constitutes what may be termed the "field proof." Section (b) constitutes laboratory work preliminary to experiments which will furnish the requirements of sections (c) and (d). These latter constitute the "experimental proof."

As regards *Rosellinia arcuata*, the requirements of rule (a) are amply satisfied. Every dead and dying tea bush from a Rosellinia patch bears in abundance the characteristic black mycelium of the fungus *Rosellinia arcuata*. The field evidence is so strong that the mycologists of the tea stations of Java and India as well as of Ceylon, have accepted it as sufficient proof of the parasitism of the fungus. " It is true that the majority of fungi described as the causes of plant disease have not undergone experimental tests, although it will be admitted by most experienced pathologists that a large proportion of the claims are just beyond all question " (Duggar, *loc. cit.*). The field proof of the parasitism of *Rosellinia arcuata* is so clear that experimental proof in this connection has been said to be " purely academic." It is, however, the purpose of the writer to supply the " academic " interest.

Until last year *Rosellinia arcuata* was known in Ceylon as a disease of adult tea only. It had not previously been recorded as a disease of tea seedlings. In February, 1927, the disease occurred in an estate nursery. The affected plants suddenly wilted and died; the collar region and some of the roots were enveloped by a black fungus having the characters of the species *Rosellinia arcuata*.

EXPERIMENT I.

Specially selected fragments from the collar regions of seedlings naturally infected by *Rosellinia arcuata* were placed around the collar of a healthy tea seedling, growing in a pot in the laboratory verandah. The seedling was one of twelve which were well-grown basket plants four months earlier, when each was transplanted into a 12 inch pot. The plants had made good growth since transplanting, and were healthy and vigorous. As the infected material had been lying in the laboratory for a few days and had dried out somewhat, the pot in which the material was placed was covered by a bell jar for 4 days to encourage the growth of the fungus. At the end of that period it was seen that the fungus had grown out of the diseased material and had reached the collar of the seedling, so the bell jar was removed.

Two months later, this plant began to wilt; the leaves drooped and dried out. On examination, it was found that the collar region at soil level for a length of about one inch was enveloped by a black fungus which proved to be *Rosellinia arcuata*. The tissues below this fungus were dead, but all the roots were healthy.

The eleven control plants remained healthy.

EXPERIMENT II.

For this experiment a pure culture of *Rosellinia arcuata* was used. The fungus was isolated from the roots of a mature, naturally infected bush. The fungus was transferred from pure culture to sterilised blocks of tea wood about half an inch cube, and was grown on this medium for one month in sterile closed tubes. Three of these blocks were then buried just below the surface of the soil and around the collar of one the seedlings which had been used as a control in the previous experiment. Care was taken not to injure the seedling during this operation.

After two months the leaves of this seedling drooped and dried out. As the wilted plant made no sign of recovery, it was carefully removed from the pot nine days later for examination. The black mycelium of *Rosellinia arcuata* was found in abundance around the collar for a distance of about 2 ins. along the tap root. The fungus was present on some of the upper roots, along which it was growing from the tap root outwards. The majority of the roots were healthy.

Three similar but uninfected plants were kept as controls. These remained healthy, and were still healthy and vigorous 6 months after the termination of the experiment.

EXPERIMENT III.

For the third experiment, five seedlings were raised together in a 12 inch pot. Three pieces of Rosellinia-infected wood were buried, as in Experiment 2, around the collar of the central seedling. Two months later this seedling died, and the photograph shown in Plate V. was taken. The plants were left undisturbed for 5 months. During this period a fungus grew out from the drainage hole at the bottom of the pot and formed a sheet on the wooden table on which the pot was standing. This fungus proved to be *Rosellinia arcuata*. When the pot was removed to a new position, the same fungus again formed a practically pure growth on the table below the pot.

When the plants were removed from the pot, five months after the central plant died, the plants surrounding the central dead seedling were found to be quite healthy. The roots of two of these, together with those of the diseased plant are shown in Plate VI.

Mycelium of *Rosellinia arcuata* was found along the entire length of the tap root of the infected seedling, and along some of its fine feeding roots. Many of the latter, however, were apparently free of the fungus, though dead. No difficulty was experienced in recovering and identifying the original fungus (Rosellinia), used for this and the previous experiments.

It is worthy of note that although the soil was thoroughly permeated with rootlets of the surrounding plants, none of these had become infected by Rosellinia. It would appear that the feeding roots of tea are immune to this fungus. Rosellinia will attack seedlings at the collar or tap root, if sufficiently grown, and will invade the woody roots of older tea, but not the fine feeding roots. This observation is perhaps of interest in that it confirms what has been suspected to be the case from field observations.

The above experiments furnish experimental proof of the parasitism of *Rosellinia arcuata* as prescribed by the canons of Koch. A diseased condition, similar to that observed in the field, has been induced in these experiments by means of naturally infected tissue and by pure culture of *Rosellinia arcuata*, and the same fungus has been found abundantly associated with the diseased condition so caused.

It has been stated elsewhere that the generally accepted view of the parasitism of *Rosellinia arcuata* (among other fungi) is unfounded; that *Rhizoctonia bataticola* is the only parasite of present importance in the causation of root disease; and that without a preliminary attack by the latter fungus, *Rosellinia arcuata* is incapable of causing disease. These statements were kept in view during the course of the above experiments.

Rhizoctonia bataticola is said to attack the smallest feeding roots, and after establishing itself there, it grows inwards and upwards, always getting nearer the larger roots, killing as it goes. Considerable emphasis has been laid on this mode of attack.

It is also stated that attempts to reproduce Rhizoctonia infection in Uganda and Ceylon have shown that the conditions of laboratory experiments do not conduce to rapid infection.

In the above experiments the control plants were in no way different from those used for infection with Rosellinia. As, in each experiment, the seedling infected with Rosellinia died two months after inoculation while the control plants remained healthy, there appears to be no valid reason why Rhizoctonia or any fungus other than Rosellinia should be suspected to have played a part in causing the deaths.

Incidentally, no experiment has yet been published to show that *Rhizoctonia bataticola* is capable of causing the death of a tea plant, nor yet of infecting healthy tea roots. Nor is there any method of

PLATE V.

ROSELLINIA INFECTION EXPERIMENT.

The arrow indicates the infected plant.

distinguishing a normal healthy tea plant from an apparently healthy one, which has some of its roots parasitised by *Rhizoctonia bataticola*, except by a minute examination of the whole of its root system. An examination of this nature before infection experiments is out of the question, though it is easily carried out on completion.

That was done after each experiment. The soil was carefully washed away from the roots of each dead or healthy plant to be examined, so that the roots were damaged as little as possible and no roots were lost.

In experiment 1, the infected seedling was removed from its pot immediately after the plant had definitely wilted. All the fine feeding roots were found to be alive and apparently healthy. No trace of *Rhizoctonia bataticola* could be found on them. As already stated, a black mycelium occurred around the collar region, about one inch in length, below which the tissues were dead. In order to ascertain whether *Rhizoctonia bataticola* or any fungus other than Rosellinia was present, this region, together with a little apparently healthy tissue at each end, was carefully washed in sterile water and placed on a sterile culture medium. Several fungi other than Rosellinia were isolated, but although the diseased tissue and its surrounding medium were kept under observation for several months, no sign of *Rhizoctonia bataticola* was seen. Each fungus, isolated from this tissue, was tested for parasitism on tea seedlings, but all the seedlings inoculated remained healthy, even after six months. They must, therefore, be regarded as secondary fungi which played no active part in causing the death of the seedling. The failure to find any trace of *Rhizoctonia bataticola* after very thorough investigation definitely proved that this fungus was not concerned, either primarily or secondarily, in causing the diseased condition observed.

After experiment 2, a thorough examination of all the fine rootlets, tap root, and collar of the infected plant failed to reveal the presence of *Rhizoctonia bataticola*.

In experiment 3, the infected and control plants had grown in a soil common to all, in a single pot before the experiment started. The feeding roots formed a dense mat thoroughly permeating the soil, such that individual plants could not be separated until all the soil had been washed away. Consequently, there is no reason to believe that any one of these plants would be more liable than any other to a preliminary attack by *Rhizoctonia bataticola*. Alternatively, if the roots of one seedling had been attacked by *Rhizoctonia bataticola*, the same fungus would be found on the interlacing rootlets of the other plants.

The condition of the rootlets of the plants adjacent to the Rosellinia infected seedling can be roughly judged from the photograph reproduced on Plate VI. All the roots were perfectly healthy,

and very careful examination failed to reveal the presence of *Rhizoctonia bataticola*. Neither the tap root nor the few remaining rootlets of the Rosellinia infected plant bore any symptom of Rhizoctonia attack, nor could that fungus be found.

The failure to find any symptom or trace of the fungus *Rhizoctonia bataticola* on any of the plants killed during the course of these experiments, and on the roots of the other tea seedlings grown with them (experiment 3) indicates clearly that this fungus had played no part whatever in causing the diseased condition. It also demonstrates that the claims made concerning this fungus, in its relationship to what is commonly termed the Rosellinia disease of tea, are unfounded.

The experiments prove conclusively that *Rosellinia arcuata* is a virulent parasite of the tea plant. It will attack and kill tea seedlings without the assistance of a preliminary attack by any other fungus, and in the absence of environmental conditions unfavourable to the tea plant. That Rosellinia will not attack or feed upon fine feeding roots of tea is shown in experiment 3. Its attack is always directed upon the woody parts of the plant; with tea seedlings, the collar, at or just below the soil level, is a suitable place for attack.

In short, these experiments confirm what has been known or suspected for many years from field evidence alone, concerning the parasitism of *Rosellinia arcuata*.

THE AIM OF FIELD EXPERIMENTS, II.

By

T. EDEN, M. Sc., A.I.C.

In the last number of this journal some of the difficulties which face the field experimenter were enumerated and explained. The elementary principles upon which an adequately designed experiment must be based were set forward, and special mention was paid to the question of the comparability of plots. In this connection, soil heterogeneity was emphasized as being the main stumbling block in the way of its achievement. Having so far dealt with the general aspects, it remains to consider experimental design in rather more detail.

When all the precautions outlined in the previous article have been observed, there still remains sufficient local soil heterogeneity and crop individuality to produce errors of sometimes considerable size. No amount of ingenuity can eliminate these errors entirely, but they can be greatly reduced, and, what is of even greater importance,

ROSELLINIA INFECTION EXPERIMENT.

PLATE VI.

they can be estimated with precision. It is in the nature of an article of faith with an experimenter that he must know the size of the errors under which he is compelled to work. Experience has shown that it is never safe to assume that differences between treatments are significant, until evidence can be tabled to show that they are in excess of those which could quite easily be produced by chance. Chance in nine cases out of ten takes the form of soil heterogeneity and, in tea, bush to bush variation.

Discussion as to how the estimate of error is arrived at is beyond the scope of this article, but this much should be said,—an error is a statistical value which is readily calculable from any well designed experiment. It shows the limits of variation which any given value might have assumed if, for instance, the same experiment had been conducted independently under similar conditions. Since the conception of experimental error is one which will be frequently brought to the notice of readers of the *Tea Quarterly* it may be as well to familiarise them with the convention that, to establish the significance of a value (e.g., the difference in yield of one treatment from another), the value must exceed at least twice the "standard error" and three times the so-called "probable error."

There are four methods by which the error of an experiment may be reduced, viz:—

(1) By having several plots of each treatment at the same time.
(2) By repeating the experiment over a period of years.
(3) By employing the best size and shape of plot.
(4) By employing the best arrangement of the plots amongst themselves.

It is usual to take advantage of all these methods, for the one reacts upon the others, as will be shown.

It is in the first place essential to have more than one plot of each treatment, because not only are the errors usually inconveniently high with single plots, but without replication it is impossible to determine the error. The assessment of an error depends upon having a number of values to compare, which are experimentally (though not actually) alike. The more plots one has, the smaller will be the error, but the error does not diminish in proportion as the number of plots increases. In order to halve the error, the number of plots has theoretically to be quadrupled, and for other reductions increased in like proportion. There comes a time therefore when any further reduction in error is only attained at the cost of a cumbersome number of plots covering an unwieldy area. One has always to keep these practical considerations in mind.

The repetition of a trial over a number of years makes for greater accuracy, and furthermore is not rendered less necessary by having

a number of replications in one year. Climatic effects are so variable that a treatment may do well in one year and hardly make any difference in another. A term of years is consequently necessary to get a fair verdict.

The size of plot is of great importance. Plots may be so small that the least trace of soil variation will make one plot distinct in productivity from another, and with small plots differences in individual bush vigour will exert a preponderating effect. To go to the other extreme is equally bad, for it is more usual to find relatively uniform soil conditions in moderate-sized tracts than over large areas. Here again labour conditions are a consideration. Given a piece of land of a certain size, a larger number of smaller plots will always assure better results than a smaller number of larger ones, down to a certain limit of number and size. It will be seen that what is required is to investigate these limits of number and size of plots with respect to the magnitude of error they produce. When this is done the available land can then be used to the best advantage. This problem of limits is being investigated at Nuwara Eliya.

It is not infrequently objected that small plots are of no use to the practical man. The idea behind this statement is obviously that, although a small plot may give a certain response, a similar one could not be expected from a large area. This objection, if it is valid, is undoubtedly a serious one and merits consideration.

In the first place the declaration of this view is merely another way of expressing the very natural fear of soil heterogeneity. In an experiment covering a few acres, it would in all probability happen that any one treatment had only a fraction of an acre devoted to it. The burden of the complaint is that this fraction is not representative in production of a practical-sized area, such as the two or three acres covered by the experiment itself. The practical man feels safer if he can speak in terms of acres rather than in fractions of them.

If the principles which have been stressed in these articles are adhered to, then complete assurance can be given to the practical planter that his fears are groundless. For herein lies the value and absolute necessity of knowing the experimental error. That error is a measure of the representativeness of the small plots. If small in size it tells him not only that the half dozen plots are representative of their combined area, but of the whole area of land over which they are scattered in the course of the design of the experiment.

Even if it were considered that an experiment of two or three acres will not give yields comparable with that obtained over larger areas, the validity of the trial still stands unassailed. It is the differences between comparably situated treatments which matter, and not the particular level of production attained by any one of them. The latter is bound to vary from locality to locality, but even so, the funda-

mental importance of a given treatment can be established. This is all an experiment can give, and is all it is fair to demand of it.

Of the four methods for reduction of plot errors, there remains the arrangement of the plots. Little can be said here, except that the effect is considerable and that the experimenter should be alive to it. In addition, experiments should always be designed so that the treatments dovetail into one another. For example if two kinds of nitrogen are being tested in varying quantities, the variations should correspond in each case. Consider three quantities. Any question regarding the kind of nitrogen can be determined from all the varying quantities considered together, from three plots of each instead of one. Any question of quantity can be settled using both kinds together, and so on, with consequent reduction in error.

This survey of aims and possibilities would not be complete without referring to the advantages and disadvantages which result from a previous knowledge of the productivity of the experimental area. It is sometimes customary to use a knowledge of the yield from the plots before treatment to compensate the results of subsequent treatment on what is known as the "percentage increase" system. If plot A untreated gave a 10% better crop than B untreated in the same year, it is held that next year, when B is treated and A left as control, a ten per cent. increase can be made to B in order to bring it to its true comparable level of production. Unfortunately, though A will in all probability maintain its superiority, it is certain that the 10% level will not be rigidly observed. By making the assumption of stability one introduces a new and variable error, one which cannot possibly be calculated. Such a procedure thus violates the canons of sound method and defeats its own ends.

There are nevertheless great advantages in knowing the previous history. Such knowledge enables one to choose as regular a tract of land as possible, discarding uneven areas. In so far as it throws light on fertility slopes, it is a great help in determining the arrangement of plots. Then, in any experiment where good plots remain consistently good from year to year, a shorter period of years is required before a fair answer to the problem tackled can be obtained.

If, in conclusion, the impression has been given that experiments are complicated things and that the introduction of statistical conceptions only tends to bewilder the non-technical reader, two points should be borne in mind. Complications are not introduced for complications' sake, but only because research has shown that the old simple experiments lack certainty. From the experimenter's point of view the old methods would save him much time and trouble if only he could rely on them. In the second place, the attitude that field experiments should be simple to study, and all plain sailing, is at

variance with that generally adopted in respect of other branches of research,—mycological, entomological, and chemical. In these cases the methods of arriving at conclusions are recognised as being specialised and technical, and the intricacies of culture preparation and analysis are not viewed with disfavour. The same view should be taken of field experiments, for, though the methods may be elaborate, if the experimenter says plainly, as he should, what the assured results are, the true aim of field experiments will have been attained.

FOMES LIGNOSUS.

By

T. PETCH.

In *Tropical Agriculture* for May, 1928, Professor Briton-Jones, discussing diseases of Limes in Dominica, writes:—

" Before discussing the several factors which have contributed to the epidemic in Dominica, it may be noted that on several of the diseased roots examined there was found a mycelium growing on the bark which agrees with descriptions of *Fomes lignosus*. It is not possible, however, to identify this white mycelium from many others. Dead stumps and trunks of lime trees left lying about on the ground after the trees had died were invariably found to develop the fruiting bodies of *Fomes lignosus*. They have also many times been observed in the dead halves of branches still on the trees. Thus there is as much evidence for the parasitism of *Fomes lignosus* as is given by Petch [*Diseases and Pests of the Rubber Tree*, **1921**]. This fungus has also been recorded as a parasite of Cacao. It is extremely common on felled Castilloa rubber trees in Cacao plantations in Trinidad, and although close watch has been kept on it for a year or more in certain sections, no sign of the spread to cacao has been observed. At present it is not eliminated entirely as a possible factor, but these observations strongly support those of Small. It is not a primary parasite and if it contributes at all towards the killing of the plant, it is in the capacity of a very weak parasite. It is of no consequence whatsoever from the practical standpoint."

There are several points in the above account which do not agree with Ceylon experience regarding *Fomes lignosus*, but I do not wish to waste space on details. The chief point is that my book on the *Diseases and Pests of the Rubber Tree* was written, as stated in the preface, " to provide the planter with a means of identifying and dealing with known diseases." Hence the accounts of the various diseases enumerated therein are, in the main, descriptive, and they do not discuss the question, or give proofs, of parasitism.

Proof of the parasitism of the Eastern *Fomes lignosus* was given by Bancroft in a *Bulletin of the Department of Agriculture of the Federated Malay States*. Objection may be taken to Bancroft's experiments on the ground that his infecting material was a naturally-diseased root of Hevea, and not mycelium of the fungus from pure culture. In such circumstances, it is possible that some other organism, in addition to the Fomes, may have passed from the diseased root to the experimental plants. But all attempts to infect woody plants with *Rhizoctonia bataticola* in that way have failed, and it has been laid down that the latter fungus does not spread by contact. Hence, as between *Rhizoctonia bataticola* and the Eastern *Fomes lignosus*, Bancroft's experiments are conclusive.

It may be as well to deal here with another misconception regarding my books on plant diseases, namely, the contention that the accounts of diseases therein are misleading, because they do not refer in each case to more than one fungus. It is difficult to understand why such an argument was put forward. Its sponsor has at his disposal at least a dozen books on plant diseases written for the enlightenment of the farmer or grower, and he is in a position to know that the style of description adopted in my books is that employed in all books of the kind which are intended for non-technical readers.

The behaviour of "*Fomes lignosus*" in cacao in the West Indies is evidently quite different from that in Ceylon. In one case in Ceylon, on a mixed estate of cacao, rubber, and coconuts, a rubber tree at the head of a small valley was attacked by *Fomes lignosus* and died, and no treatment was applied. The mycelium spread down the valley, killing all the cacao and coconuts in its path.

The difference between the behaviour of the fungus in the East and West Indies respectively, judging from published experience, is so striking that some explanation is needed. The explanation is quite simple. The "*Fomes lignosus*" of the West Indies is not the same fungus as the "*Fomes lignosus*" of the East Indies.

For some time I have been endeavouring to clear up the identity of our tropical root disease fungi, and a paper on this subject, written in 1926, will, I expect, shortly appear in the *Transactions of the British Mycological Society*. van Overeem, in Java, gave a lengthy list of synonyms of *Fomes lignosus*, but he merely collected the various suggestions which have been made by mycologists who have tried to remedy the confusion which exists as regards tropical species, and he did not take the essential step of examining the type specimens. Hence his work is purely literary. Even as regards Javan fungi, as his figures show, van Overeem failed to distinguish between "*Fomes lignosus*" and the common saprophytic *Polyporus zonalis*.

From an examination of specimens in the Kew, British Museum, and Paris herbaria, it appears that the correct name of the fungus

which is known as *Fomes lignosus* in the West Indies is *Polyporus microporus* (Sw.) Fr. It is apparently a common fungus on fallen branches, a habitat which, in my experience, is unknown in the species which passes under the name of *Fomes lignosus* in the East.

I have not yet seen the type of the true *Fomes lignosus*, which is in Herb. Berlin, but from the opinions of those who have seen it, it is the same as *Polyporus microporus*. In that case, West Indian mycologists are not wrong as regards the species in using the name *Fomes lignosus*, though the earlier name, *Polyporus microporus*, should be used, and the name *Fomes lignosus* discarded as a synonym.

But the Eastern fungus is not the same species, and it cannot be known either as *Polyporus microporus* or *Fomes lignosus*. The statement that the type of *Fomes lignosus* (Klotzsch) Fr. came from Mauritius appears to be a mistake. Klotzsch described in the same paper specimens from Mauritius, India, North America, and St. Vincent, but he did not give a locality for *Fomes lignosus*. It is quite as likely to have been from the Western Hemisphere as from the East.

To sum up, the position appears to be that:—

(1) *Fomes lignosus* (Klotzsch) Fr. is a synonym of *Polyporus microporus* (Sw.) Fr., and should be discarded.

(2) The fungus known as *Fomes lignosus* in the West Indies should be known as *Polyporus microporus*.

(3) The correct name of the fungus which is called *Fomes lignosus* in the East Indies is not known.

The foregoing illustrates a point which is well-recognized among mycologists, viz., that any attempt to correlate the diseases of one country with those of another must depend upon the correct identification of the fungi concerned. If the accounts of what is supposed to be the same disease in the two countries are so opposed to one another as those of *Fomes lignosus* in the East and West Indies respectively, that should lead one to suspect that there has been an error in identification.

CALLUS.

By

T. PETCH.

When woody plants are wounded down to the wood, either by cutting across a stem or by shaving off the bark (cortex), growth takes place from the cambium which has been exposed at the margin of the wound (between the wood and the bark), and this results in the formation of a ring of tissue, often somewhat swollen, surrounding the wound. This tissue gradually extends over the exposed wood of the wound, and in favourable circumstances the growth from the sides may meet in the centre and coalesce, thus forming a completely closed covering over the wood.

This tissue is known as callus. It is the natural means of healing wounds on woody stems. All woody plants should be capable of callus growth, though the rate of growth is slower on old trees and stems than on young ones.

While the callus is growing over the exposed surface, it forms an outer protective layer of cork and an internal cambium which is continuous with the original cambium of the stem. When the ingrowing edges meet and close together over the wound, their cambiums unite and form a continuous cambium, continuous with the original cambium of the stem, so that new wood and bark is formed over the wound, just as on other parts of the stem.

The wood which was exposed by the wound does not unite with the new wood formed over it. The old exposed surface is simply buried, and remains permanently within the stem as evidence of the wounding.

The initiation of callus growth is not necessarily confined to the margins of wounds. On large wounds on rubber trees, islands of callus may appear in the middle of the wound, arising from the ends of medullary rays which have developed an independent cambium.

Tea, being a woody plant, should, and does, form callus, though, even on unpruned bushes, callus growth is slow, when compared with, say, callus growth on a rubber tree.

In general, the growth of callus is more rapid on young trees than on old ones. In temperate climates, the rate of callus growth varies with the time of year at which the wound is made. If made in the growing season, the rate of growth is most rapid when the callus first begins to grow and it slows down later. Thus, in the first year, a broad cushion of callus may be formed round a wound, but in subsequent years the growth becomes less, and it may cease altogether, long before the wound is covered.

Naturally, vigorous plants are in a better condition to form callus than weak plants, and anything which will increase the vigour of the plant may be expected to promote the formation of callus. Thus, manured tea bushes would be expected to show a better callus formation than unmanured bushes, though other considerations must be taken into account. But no experiments have ever been carried out which would justify the omission of any of the chief manurial ingredients, nitrogen, phosphoric acid and potash, from a manure mixture for the purpose of favouring the growth of callus.

That callus growth slows down as the wound becomes older is well known. The most vigorous callus growth occurs soon after pruning, unless the pruning has been done at a time when growth is at a standstill, e.g., in the winter, in temperate climates. Consequently, when tea has been manured at pruning time specially to promote the growth of callus, and no marked callus growth is evident during the next six months or so, one must count that manuring a failure from the point of view of callus formation. It is urged that that is a wrong view, and one must wait some years before expecting any response. But, when the tea receives, say, 1,800 pounds of manure per acre during the pruning cycle, it is surely illogical to attribute all subsequent callus growth to an incomplete mixture applied at pruning time. Any cumulative effect must be an effect of the whole system of manuring, plucking, and pruning.

An ideal callus should begin to develop soon after pruning, should grow evenly all round the wound, and should cover the exposed wood before it has begun to decay. Development is best over a flat surface. If the wound is a cavity, the developing callus, as a rule, does not grow down the sides of the cavity, but curves inwards at the top and forms a rolled-up edge. Thus the cavity is never closed, unless it is so small that the rolled-up margin completely blocks it.

On very oblique pruning cuts, the callus often develops only from the lower edge, forming a flap extending over the exposed wood. As previously stated, the callus does not unite with the wood, but simply grows over it. In a proper callus development, growth occurs from the margin all round the wound, and it is the pressure of the developing edges of the callus which causes them to unite, when they meet, and seal the wound. A flap which extends from the margin of the wound on one side only, may grow right over the wound, and even over the stem beyond, and yet afford no protection if there is no growing callus on the other side of the wound, with which it can unite. It will not unite with the bark of the stem, nor with a narrow fringe of callus which has ceased to grow.

An example of such ineffective callus growth is illustrated in *The Diseases of the Tea Bush*, page 126. That example is one of

several which were collected on one estate about ten years ago. In some cases the plates of callus were three inches across, and extended widely over the surface of the stem. They were not fused with the stem, and as a protection they were useless,—a waste of energy on the part of the bush.

In pruning off a lateral branch, the cut should be made close to, and parallel to the main stem. In many cases, the cooly, beginning on the underside of the lateral close to the main stem, cuts outwards, so that a wedge-shaped snag is left (Plate VII., fig. 1.). Usually, a good callus develops from the lower edge, but none, or very little from the upper projecting edge of the cut, with the result that the snag remains as a permanent source of decay.

Callus does not easily grow over a projection. If a jagged piece of wood projects from a saw cut, the callus will grow over the cut surface until it meets the projection, which remains uncovered and affords a point of entry for wood-rotting fungi.

Similarly, when a pruning cut is very oblique, callus growth at the upper thin edge of the wound is poor or absent. Nearly all the growth arises from the lower edge, and this may not cover the wound, or may not unite with the callus at the upper edge. From the point of view of callus development, pruning cuts should not be too oblique, but it is difficult to avoid this when pruning thin branches.

An exception to the foregoing occurs when a bud starts just below the upper edge of the cut. In such cases there is usually a good development of callus all round the cut, probably because the new shoot maintains the supply of water and food right up to the cut. But pruning to an "eye" is impossible on old wood.

That moisture favours the development of callus, at least in the early stages, has been known for many years. There is a well known experiment, often included in elementary text books of botany, which consists of ringing a willow twig and suspending it in a damp atmosphere. The experiment concerns the translocation of food, but, incidentally, it shows a remarkable development of callus under the humid conditions.

However, further facts have to be taken into account. Experiments have recently been carried out on callus formation on hard wood cuttings, some of which were planted in a wet substratum while others were planted in a drier medium. The experiment was begun in late September. At the end of October, those in the wetter substratum were better callused than those in the drier, but, subsequently, the latter gained steadily on the others, and by the end of January they were considerably the more forward. Thus the favourable action of moisture was confined to the early stages.

It follows from the data presented here, that in collar pruning, where large cuts are inevitable, the cuts should be made nearly flat, to obtain a growth of callus all round, and should be as low as possible, to secure humid conditions.

It may be noted here that the problem of callus growth in Ceylon is the development of callus over cuts, two to three inches in diameter, and exhibitions of callus growth on branches less than half-an-inch in diameter, i.e., on young wood, evade the main point.

As already pointed out, callus grows best over a flat or even surface. It is always superficial, i.e., it cannot grow through dead wood. Where callus appears to have grown through wood, there must have been a split in the wood first. Callus cannot push out unsound wood, unless the latter is in loose fragments, or a powder, or reduced to mud.

A callus developing at the edge of a "branch canker" sometimes dies back. This may occur, even if the canker has been cleaned out and a preservative applied, but it is more common where the wound has not been cleaned out.

Callus, even if it completely seals a wound, does not necessarily stop the decay of the wood, if the latter has been infected by wood-destroying fungi before the callus was complete. Figure 2 on Plate VII. shows a branch with two perfect heals. On cutting this branch longitudinally, it was found to be decayed internally, the decay having started from each of the wounds (Plate VII., fig. 3). The level growth of callus indicates that the exposed wood presented a level surface, i.e., there was no cavity, when the callus was growing. It is clear that it was then infected, and the callus did not stop the decay. This example indicates the necessity of protecting the wood by some preservative, even though callus development is good.

Surprise has been expressed that the Institute recommends the use of preservatives, which will tend to keep the wood dry, in spite of the fact that moist conditions favour the growth of callus. There might be some excuse for that surprise if the development of callus over a wound, two to three inches in diameter, were a matter of a few weeks. In actual fact it is a matter of years. Even on tea which has been specially manured, there may be no sign of healing of branch cankers and large pruning cuts at the end of four years, and we have yet to see complete healing over a three-inch cut. Meanwhile the exposed wood continues to decay.

The promotion of callus formation is an excellent object, and it is to be regretted that its advocacy has been coupled, quite irrelevantly, with the condemnation of methods of treating wood rot. Without some treatment of the wounds, decay cannot be arrested. Moreover, the conditions are more favourable for callus growth if the cankers are cleaned out and treated, than if the callus has to grow over

1 2 3

Fig. 1, Snag (on left) after pruning, natural size.
Fig. 2, Branch showing two perfect heals, x 3/5.
Fig. 3, Longitudinal section of same specimen, showing internal rot.

irregular unsound wood. In the present state of Ceylon tea, callus development is supplementary to treatment of wood rot; it cannot replace the latter. It is folly to allow wood rot to proceed without treatment, in the hope of obtaining a covering of callus in, say, ten years time.

The view that the decay within a "branch canker" will be arrested by the formation of a wound gum barrier lacks foundation. It is merely an unwarranted deduction from investigations carried on in temperate climates. No one has yet found such a wound gum barrier in Ceylon tea.

Further, as was stated in the *Tea Quarterly*, Part 2, pp. 29, 30, the scientists who have carried out these modern investigations recommend the use of preservatives for covering wounds. In this country, the results of these investigations are being misunderstood and misapplied.

Any method which will tend to improve the vigour of the tea bush is to be welcomed. But it should not be supported by mistaken arguments which decry other treatments, to the detriment of the tea industry. If the present scale of manuring is justified by the increased yield, well and good. But Directors must not imagine that they are thereby carrying out an efficient treatment of wood rot.

I am indebted to Dr. C. H. Gadd for the photographs on Plate VII.

TEA WITHERING. MECHANICAL INNOVATIONS.

The following is a summary of information concerning two recent innovations claimed to facilitate the withering of green leaf, and to make the process independent of climatic conditions, while effecting a saving in personnel, withering space and power.

In *De Bergcultures*, No. 34, February, 1928, an article by Herr Hoekstra, entitled, "Droog-en Verflenstoren. O.A., No. 546 Ind.," describes a chimneyed tower of square or rectangular section, which can be used for drying rubber, coffee, copra, and also for withering tea leaf.

The size of the tower, which is surrounded by heat insulating material, depends on the crop to be dried and the capacity required. Where more than one tower is needed to deal with the crop, a series of towers may be built in a group in such a way as to be supplied with hot air from the same pipe. The cost of one tower including racks for withering, but without hot air oven, and capable of withering about 1200 lb. of green leaf in 15 hours is given as 4,750 florins.

The tower may be easily filled and emptied through two sliding doors at the bottom; and, when used for withering purposes, the leaf introduced through these doors is spread on racks fixed in cages, each of which is suspended through its central axis from a shaft, the ends of which are fixed in the links of two endless chains travelling up and down on opposite sides of the tower. In this way the cages ascend the tower on one side and descend on the other, the resulting circulation of the load ensuring uniform treatment of all the leaf. The vertical equilibrium of the cages is maintained by placing a heavier load in the bottom half, so that when the cage is tilted over through half a revolution and then allowed to return to its stable position the leaf on the racks is turned over. This can be done at any time, while the cages can be emptied at the bottom of the tower by a similar operation, when the withered leaf falls out through one of the two doors.

The chain wheels are set in motion by turning an extra-mural wheel, which is so geared as to require little power, and the tension set up by the loaded cages on the axles of the upper chain wheels is taken by laminated springs, whose movements are recorded on two dials fixed on the outside of the tower, thus indicating the weight of leaf carried at any time. The driving wheel may be turned by the use of electric power, in which case the load can be determined by means of an ampere-meter, so that the rate of loss of moisture or degree of wither is easily determined.

Inspection and ventilating doors are fixed at various heights, and allow examination of the product at any time.

Preheated or dried air can be brought from a separate drier to the bottom of the tower by means of a pipe, which is connected with flues running up the sides on which the cages travel. It is possible to control the total amount of air drawn into the flues by the draught of the chimney, and the draw of the chimney may be augmented by the use of a fan. The air from the flues enters the tower at different heights through traps which can be opened and closed at will.

The advantages claimed for the tower are:—

(1) It is possible to spread the leaf thickly without danger of stewing, but this has not been demonstrated.
(2) Saving in personnel.
(3) The leaf undergoes uniform treatment.
(4) The rate and degree of wither can be accurately gauged.
(5) The temperature during withering can be easily controlled.
(6) The natural draught created by the chimney does away with the use of powerful fans, while the draw of a fan, if used, will be more effective than in a wide loft.

A tea withering machine built by Messrs. Marshall, Sons & Co., Ltd., of Gainsborough, U.K. is described in Tropical Life, No. 273, March, 1928. The product of this machine has been tested, and it is claimed to be practically the same as tea made after a natural wither.

The witherer, which is similar in design to a drier, is made in two sizes, 9 ft. and 6 ft. wide—the output of the 9 ft. type being 1200 lb. of withered leaf per hour with an expenditure of $12\frac{1}{2}$-15 B.H.P., while the smaller machine turns out 800 lb. withered leaf for an expenditure of $5\frac{1}{2}$-$6\frac{1}{2}$ B.H.P. The best way of withering is to spread the leaf overnight, and then pass it through the machine early next morning. The leaf is then fed from a raised platform on to travelling trays which occupy the whole width of the machine, the feed opening being at the top of the machine. The trays containing the leaf travel to and fro in the machine on roller-type chains at certain definite speeds which can be regulated so that the leaf takes 13, 18, 24 or 35 minutes to complete the circuit, before it finally emerges at the bottom of the witherer and is collected in a trolley ready for the rollers.

Tubular stoves are recommended as a source of hot air, which is forced into the withering machine by a fan placed at the bottom, while another fan placed on the top draws out the moisture, the temperature of the ingoing air being recorded on a thermograph.

The advantages claimed for the machine are:—

(1) A saving in capital outlay, lower production costs, and a greater convenience in factory working.

(2) A saving in spreading or rack area of 75%.

It is understood that this machine is under trial on a Ceylon estate.

D. I. EVANS.

THE INSULATION OF DRIERS.

In *De Bergcultures*, 2nd Jahrg., No. 38 (March 17, 1928), Dr. J. J. B. Deuss gives details of a trial of fuel consumption in insulated and uninsulated driers. Four Java driers were used, two of them being insulated with Eternit, while the other two were not insulated. The duration of the test was seven hours, the driers being maintained at a temperature of 210°F. The fuel used was cinchona wood, which has a weight of 383 kilos per cubic metre and is a good fuel.

The amount of fresh leaf dealt with was 15794 half kilos. That was withered to 60 per cent., and after withering, rolling, and fermenting, weighed 9510 half kilos. The out-turn of dry tea was 3364 half kilos, the ratio of fresh leaf to made tea being thus 4·69 to 1.

In the two uninsulated driers, 5440 half kilos of fermented leaf were dried to 1886 half kilos of dry tea. The amount of water evaporated was 3554 half kilos and the fuel consumption 1079 kilos (1 kilo = 2·2 lb.). Thus, to evaporate 1 kilo of water, 0·607 kilos of wood were required, or for each half kilo of withered leaf, 0·19 kilo of wood.

In the two insulated driers, which were somewhat smaller than the others, 4070 half kilos of fermented leaf were dried to 1478 half kilos of dry tea. The amount of water evaporated was 2592 half kilos, and the fuel consumption 703 kilos. Thus, to evaporate 1 kilo of water, 0·542 kilos of wood were required, or for each half kilo of withered leaf 0·17 kilos of wood.

As the quantity of water which must be evaporated in a day's work is about 6200 kilos, the saving by insulating the driers is 403 kilo of wood, or about a cubic metre of cinchona wood per day, a saving of about 20 per cent.

T. PETCH.

BLISTER BLIGHT IN INDIA.

In the *Quarterly Journal of the Scientific Department of the Indian Tea Association*, Part 1, 1927, Mr. A. C. Tunstall, the Mycologist of the Association, records the occurrence of Blister Blight (*Exobasidium vexans* Massee) on Tea in the Surma Valley in the districts of Sylhet and Cachar. From the various localities from which the disease has been reported it appears that it is now distributed all over the northern part of the Surma Valley.

Blister Blight was first mentioned in India about the year 1868, but even in 1903 Watt and Mann were able to write, " So far as we have been able to observe, this blight is, and has always hitherto been, exclusively confined to Upper Assam. It has never been definitely reported below the Jorhat district on the South, and the North Lakhimpur district on the North, bank. It has never visited either Cachar, Sylhet, Darjeeling, or the Duars."

For about forty years, Blister Blight was known only in Upper Assam. In 1908, however, severe attacks broke out in the Darjeeling district, and since that date it has been permanently established there.

Thus, the first appearance of the disease was in the extreme North-east of the tea districts of Northern India. Forty years later it appeared in the North-west corner. And after about another twenty years, it has been found in the extreme South. It may be said that Blister Blight now occurs at the three corners of the triangle covered by the North Indian tea districts.

It was formerly stated that Blister Blight would flourish only in the cooler tea districts, where the fungus may be found at any time of the year on bushes growing in damp shady places. Its occurrence in Cachar and Sylhet, however, negatives that idea, and it must now be considered probable that the disease will be found capable of existing in any tea district.

In the present state of our knowledge, it is difficult to formulate any explanation of the extraordinary manner in which this disease has extended its range. Practically it has jumped successively from one corner of the tea area to another. As far as natural agencies are concerned, one would suggest that each of these three major infections was independent of the other, and was due in each case to infection by windborne spores from some plant in the jungle. *Exobasidium vexans*, however, is not known to attack any plant except tea. Tunstall states than an Exobasidium occurs on *Camellia drupifera* in the jungle to the north of the Surma Valley, but it is a different species. Consequently, the idea of infection from neighbouring jungle lacks support.

It was formerly suggested that Blister Blight of tea was identical with a similar disease of Rhododendrons, and that the Darjeeling out-

break was due to an infection from the Rhododendrons on the Himalayas. That idea appears to have been abandoned. If it were true, we should expect to find Blister Blight on tea at high elevations in Ceylon, since the Ceylon tree Rhododendron is commonly attacked by *Exobasidium Rhododendri*, which produces, on the Rhododendron leaves, blisters similar to those caused by *Exobasidium vexans* on tea. The absence of Blister Blight from the tea in the neighbourhood of the infected Rhododendrons is evidence against the view that the Blister Blight of tea originated from that plant.

Tunstall states that it is difficult to account for the present distribution of the disease in the Surma Valley except on the assumption that the spores have been conveyed by the wind, but he is unable to suggest whence they were derived, in the absence of a detailed mycological investigation of the jungles on the hills to the north of the Valley. Here we meet with a difficulty which crops up repeatedly in pathological investigations, viz., that, except in some temperate countries, where the work has been carried out by amateurs, no one knows what fungi the forests or waste lands harbour. Some day it may be realized that a knowledge of the fungus flora of a country is often as important as a knowledge of its flowering plants.

The possibility of the transference of the disease to the Surma Valley in consignments of seed was investigated by Tunstall, who states that in none of the cases investigated had any seed been imported from infected areas for over a year previous to the appearance of the disease, and that the distribution of the disease on the individual gardens did not favour the suggestion that the spores were introduced with seed.

Against that it may be remarked that, supposing that the spores of Blister Blight were transferred with tea seed, one would not expect a widely-distributed attack on mature tea in the year the seed was imported. The first appearance of the disease would be expected to occur in the nursery, and if it was overlooked there, it would spread to mature tea.

Further, the occurrence of Blister Blight at the same time on estates " all over the north of the Surma Valley " does not favour the view that the infection of the district occurred in the season when it was first observed.

There is, as yet, no adequate explanation of this periodic extension of Blister Blight through the tea districts of Northern India, and in these circumstances it would be unwise to relax the regulations against its possible introduction into Ceylon.

As previously recorded elsewhere (*Diseases of the Tea Bush*, p. 85), Blister Blight of tea occurs in Japan and Formosa. It has also been recorded from Italy, on tea in the Botanic Garden at Pavia.

T. PETCH.

NEWLY-RECORDED FOOD PLANTS OF SOME PESTS OF TEA AND GREEN MANURES.

By

S. STUART LIGHT, D.I.C.

During the past two years, observations have been made on the food plants of certain pests of tea and shade trees, and a number of new records have resulted. The present article deals with these records, and also includes notes of interest on the relations of certain pests to host plants already recorded.

Scarlet Mite (*Brevipalpus obovatus* Donn.) has been newly observed on a variety of plants,—*Acacia Melanoxylon*, *Salvia coccinea*, and several Composites, viz., *Bidens chinensis*, *Sonchus arvensis*, *Galinsoga parviflora* and *Gynura lycopersicifolia*. On young Grevillea trees, 5-7 ft. in height, growing in a field badly attacked by this mite, it was observed that many of the leaves showed very noticeable browning. On closer inspection it was found that this appearance was due largely to the presence of Red Spider on the upper surface of the leaves, but Scarlet Mite was also present in some abundance on the reverse side, producing a blackish, somewhat shrunken effect. No mites were observed on seedling Grevilleas planted out in the field, or on full-grown trees.

In the case of *Acacia Melanoxylon*, a slight infestation was observed on young trees bordering the field referred to above. Scarlet Mite was also found on *Bidens chinensis* and *Sonchus arvensis* in scrub land adjoining the same field; on the former the mite is sometimes abundant and eggs appear to be laid freely. The remaining records were made on an abandoned estate in the process of reclamation. Weeds, including again *Bidens chinensis*, growing profusely around several small nurseries, were found to be attacked. Many of the seedlings in the nurseries had been killed out by the mites, which probably migrated from the surrounding weeds. In Java, Scarlet Mite has been recorded from a number of weeds, including *Bidens pilosa*.

Caterpillars of the Geometrid moth, *Boarmia acaciaria* Boisd., which is allied to the Tea Looper (*Boarmia bhurmitra* Wlk.), have lately been taken on tea bushes. In the laboratory the caterpillars fed readily on tea, and the moth was bred out without difficulty. The full-grown caterpillar is coloured a dull olive-green, and attains a length of about 2 inches. The pupa is brown, and about $\frac{3}{4}$ inch in length. The moth is greyish white, marked with grey-brown wavy lines, and is $1\frac{1}{2}$-$1\frac{3}{4}$ inches across the outspread wings.

Psyche vitrea Hmpsn. and *Chalia doubledayi* Westw., both of which are bag-worms (Psychidae), were recorded on Albizzia for the first time in 1927. They are normally pests of tea, while *Psyche vitrea* has been recorded also on rubber.

As regards *Psyche vitrea*, the curious thing about the attack was that although the bag-worms spread to the tea, they did little damage there, while many of the Albizzias were completely defoliated. The caterpillars were said to be present in millions. Amongst the *Psyche vitrea* were found a number of specimens of similar appearance but of much greater size; these are apparently a species of *Acanthopsyche*. *Chalia doubledayi* was described as feeding on the leaves and bark of the Albizzia trees.

These new records of attacks on Albizzia and tea, as Dr. J. C. Hutson has pointed out (*Tropical Agriculturist*, April, 1927), seem to indicate an interchange of the pests of tea and shade trees, i.e., the insects show a regrettable tendency to widen the range of their food-plants.

The mealy bug found on the roots of *Albizzia lopantha*, referred to in the Annual Report for 1926, has since been identified as *Pseudococcus maritimus* Ehrh. As described in that report, the plants were said to be dying out from a cause unknown; owing, however, to the small number of the insects occurring on the roots, their presence could not be associated with the death of the plants. The finding of mealy bugs on the roots of various green manure plants is a matter of frequent occurrence, but although on some occasions it seems difficult to attribute the death of the plant to any other cause, no evidence has as yet appeared to show that the insects are the prime factor in this event. In some cases where the mealy bugs are found on a stem just below soil level, it is discovered that they have evidently been attracted by a wound (such as splitting of the stem) in that region, where, as in the case of Woolly Aphis, so commonly found on apple trees in Europe, the bugs congregate around the wound as a ready source of the plant sap on which they feed. In such instances the insects may have migrated from the foliage.

On the roots of plants that have died, in addition to the bugs, various fungi are often found, but even these are not necessarily the primary cause of death. Where the leaves are infested with mealy bugs, the continued feeding of the insects on the foliage of the plant may induce a weakened and unhealthy condition of the roots, which are then readily attacked by different fungi. In the majority of cases mealy bugs found on the roots have little effect on the health of the plant.

Few pests of *Acrocarpus fraxinifolius* have at any time been sent in for report. Probably the most serious insect enemy of this green manure is the caterpillar of the common Terias spp. Two reports

have been received during the last fifteen months, the only previous record being that of an outbreak in Dimbula in 1924. One of the recent reports is from the same estate as the original record, the other being from Maskeliya. In the latter instance, the attack spread over practically the whole estate, so that every Acrocarpus tree was affected. Here, as in similar severe attacks on Albizzia, the caterpillars were found to drop down on to the tea, causing a certain amount of damage (*vide* Terias on Albizzia, Annual Report for 1926).

Branches of Boga medeloa (*Tephrosia candida*) were received in May, 1927 suffering from the attacks of a boring beetle, *Xyleborus discolor* Blfd., closely allied to the Shot-hole Borer of tea. The male beetle is much smaller than the female, and the elytra are lighter in colour.

In this instance the older plants (two years old) only were found to be infested. The beetle apparently bores only into the younger shoots, for the galleries in the older portions of the stems had all been abandoned. This fact points to a ready method of control,—lopping the shoots, with subsequent burning, should rid the plants of the living beetles. A few of the galleries were seen to be healed over; thus, as in the case of Shot-hole Borer, manuring might prove of benefit in combating the pest, although this method would probably not be feasible in practice with a green manure crop.

It is curious to note that in many of the older galleries small fly maggots were discovered, 5 or 6 in each gallery; these, however, are not connected with the injury to the plant, but are merely feeding on the decaying tissues surrounding the cavity of the boring. In this connection Mr. F. P. Jepson, of the Department of Agriculture, informs me that a Drosophilid fly, *Phorbia xyleboriphaga*, is frequently found in the galleries of *X. fornicatus*.

A species of Aphid, not yet identified, has been recorded on Gliricidia. The trees in question were 2-3 years old, and the insects collected on the young shoots, producing a wilted appearance. Most of the shoots, however, suffered little harm.

Shot-hole Borer attacking the green manure plant, *Derris robusta*, forms another new record. This outbreak was reported in July, 1927 on an estate in Uva, where the Derris plants had evidently become infected from the tea, which already contained the Borer.

DISEASES AND PESTS OF TEA IN NYASALAND.

The section of the *Annual Report of the Department of Agriculture, Nyasaland*, for 1926, dealing with the pests and diseases of tea in that country, has been published as *Entomological Series, Bulletin No. 1, First Report on Pests and Diseases of Tea in Nyasaland*, by C. Smee.

Among the leaf diseases, Brown Blight and Grey Blight are said to be the most prevalent, but little damage is caused to the older bushes, though new clearings have suffered to some extent, owing in some cases to the heavy growth of a cover crop, which made conditions more favourable for the development of fungi. A fungus of the Phoma type was common, and is thought to be associated with damage caused by Helopeltis.

Abnormalities apparently not due to fungi are scabbed leaves; leaves with a scaly upper surface to the midrib, a brown appearance marked transversely; and a copper-coloured sheen in irregular blotches between the veins.

Blister-like swellings on the leaves occur in considerable quantity, and are usually most prevalent where Helopeltis damage is also present. The blisters are convex and pale green on the upper surface, the concave lower surface becoming brown and scaly. Ultimately the centre of the blister cracks, leaving an irregular perforation of the leaf. The cause of these is not yet known.

The most important disease of tea, other than root diseases, in Nyasaland, is Die-back, caused by *Macrophoma Theae* Spesch. (? *Macrophoma theicola* Petch). This causes Die-back of the shoots of the older bushes, and has seriously attacked young plants and seedlings in nurseries.

A few cases of Armillaria root disease have been found on older bushes, and the ordinary treatment of removing tree stumps and applying lime has been adopted.

By far the most important and difficult trouble which tea planters in Nyasaland have to contend with appears to be the Botryodiplodia root disease. Of a large collection of diseased tea plants, 66 per cent. were found to be attacked by this disease, the plants ranging from full-grown bushes to plants one year old. Apparently it is the custom in Nyasaland to bury prunings, and the pruning is annual.

T. PETCH.

From this report it appears that entomological problems in connection with tea in Nyasaland resemble much more nearly those of North-East India than those of our own island. The practice of annual pruning which is carried out in Nyasaland should also allow

of the Indian methods of control, especially as regards chemical treatment. The chief pests of tea are Helopeltis and Red Spider, both of considerable importance in India, but of little consequence to Ceylon tea, while Tea Tortrix, Shot-hole Borer and the tea termites are not even represented in the list of pests in Nyasaland.

Undoubtedly the most serious of the Nyasaland pests is a species of Helopeltis (Mosquito Bug). *Helopeltis bergrothi* Reut., which is larger than the Indian species, is a native of West and Central Africa, and has been recorded as feeding on a variety of crops, including cotton and native gourds.

Attack is directed chiefly on young plants in nurseries and clearings, on which the bugs persist during the annual pruning. As affecting the older plants, Helopeltis becomes most abundant in February or March, while the maximum flushing period occurs during the preceding two months, so that at present it would appear that the main yield of flush escapes the chief insect attack. Yet too much stress must not be laid on this, since a re-adjustment of conditions in favour of the insect may occur.

Rainfall appears to exercise a certain influence on the insects. They begin to increase in number with the advent of the rains in December, but from May to December the numbers fall off, a period occurring between October and December when Helopeltis is practically absent from the fields. Thus hand-collection is advised, as soon as the rains appear.

Red Spider is another pest of some consequence, occurring annually in certain areas where the soil conditions require attention. The planting of Grevilleas and other trees, accompanied by improvement in drainage, has proved effective in one area.

Other pests, of lesser importance, include a species of weevil attacking the leaves of young plants, various plant-sucking bugs that cause slight damage to the flush, and grasshoppers that feed on the older leaves.

S. S. LIGHT.

FIRST LONDON SALE OF KENYA TEA.

The following note is reprinted from the *Tea and Coffee Trade Journal* of February, 1928.

The first consignment of tea from Kenya Colony to be sold on the London market was auctioned on the 18th (Jan., 1928.). The consignment, composed of 12 packages, was from the Kenya Tea Co., of Kerenga estate, and in a talk with one who was intimately concerned in the sale I gather that the quality of this initial sample was quite good, and opinion was generally quite favourable. East African circles in London are hopeful that this first sample will be followed shortly by others not only from Kenya and Uganda, but from the experimental plantations in Southern Tanganyika.

It may be recalled that in a recent report by the Director of Agriculture in the colony it was mentioned that, while in 1925 there were only 382 acres under tea, by the end of 1926 it had been increased to 1,689 acres. Now at least two leading tea-producing concerns of the world are interested in tea growing in the colony.

Tea growing in Kenya, however, is not an industry in which individual planters can show much interest, for it is best suited to a company with a capital of £25,000. Cost of production for the first four years is put at not less than £70 an acre.

The main problem to be solved is that of labour. A minimum of one and half men per acre is usually taken as a standard, and it would thus require the services of 75,000 labourers for, say, 50,000 acres. It would be impossible at the moment for such a labor force to be recruited in the tea-growing areas, but the fact that this initial supply of Kenya tea has been sold in the world's leading tea market shows that those interested in the industry are alive to its future.—H.C.D.

NEW FUNGI ON TEA IN ITALY.

Curzi, M.—*De novis theae micromycetibus pathogenis.—Atti Istituto Botanico d.r. Univ. di Pavia e Lab. Critt. Ital., Ser.* III., III., 1926, pp. 59-72; 2 *plates.*

Several years ago, Dr. J. Briosi established a plantation of tea in the Royal Botanic Garden of the University of Pavia, Italy. Dr. Curzi has given a short account of the diseases and pests which attack it, and has described several new fungi among the former. He states that the tea has grown luxuriantly, but in some years it has been so severely attacked by insects and fungi that it was feared that it would be exterminated.

The principal pests are scale insects, especially *Pulvinaria floccifera* (West.) Gr. and *Parlatoria Pergandii* var. *Camelliae* Comst.

Among the fungus parasites recorded are *Meliola Camelliae* (Catt.) Sacc., a Sooty Mould, in association with the Parlatoria; *Exobasidium vexans* Massee, Blister Blight; *Macrophoma Theae* Spesch.; *Septoria Theae* Cav.; *Hendersonia theicola* Cooke; *Discosia Theae* Cav.; *Pestalozzia Guepini* Desm., and *Helminthosporium gigasporum* B. and Br.

With the exception of the Meliola and the Pestalozzia, all these fungi are rare or very rare.

The new fungi described by Curzi are the following:—

Diaporthe theicola Curzi. Pseudostromata scattered, cortical, minute, encircled by a wavy black line; perithecia in each acervulus few (2-4), embedded in the cortex, depressed globose, with a flat base, 240-280 microns diameter; ostiola usually projecting, 70-80 microns broad; asci cylindrico-clavate, without paraphyses, 50-65 x 6-7 microns, eight-spored; spores sub-distichous, hyaline, fusoid, slightly curved ,one septate, typically not constricted; with two guttae in each loculus, 12-16 x 2·5-3 microns.

This species was found on dead branches of tea, kept on damp earth. The branches bore the pycnidia of *Phomopsis theicola* (see below), and when kept in the laboratory under the conditions stated developed the perithecia of the Diaporthe.

Leptosphaeria Cavarae Curzi. Spots white, surrounded by a brown line, subcircular and confluent chiefly at the margin of the leaf; perithecia situated above the mesophyll, covered only by the epidermis, punctiform, globose, scattered or gregarious, 65-80 microns diameter; ostiolum exposed; asci few, clavato-saccate, subsessile, paraphysate, 40-45 x 9-10 microns, eight-spored; spores obliquely distichous, or rarely tristichous, fusoid, slightly curved, three-septate, constricted when mature, olivaceous, 15-20 x 3·5-4·5 microns.

On leaves of tea.

Phyllosticta theicola Curzi. Spots few, small, 2 to 4 mm. diameter, round, whitish, with a dark margin; pycnidia epiphyllous, superficial, few, scattered, often marginally arranged, depressed, ellipsoid, covered by the epidermis, 100-150 microns long, 70-90 microns high; spores cylindric, straight, biguttulate, hyaline, 4-5 x 1·5-2 microns; sporophores short, acicular, arising from a sub-ochraceous inner layer.

On leaves of tea. Rare and causing little damage.

From the figure, the spots resemble the Bird's Eye spot caused by *Cercospora Theae* Rac., on which one frequently finds a few scattered pycnidia of a Coniothyrium.

Phomopsis theicola Curzi. Pycnidia scattered, depressed, with a flat base; ostiolum erumpent, large, parenchymatous, usually 180 to 250 microns wide, but under conditions of high humidity two or three times as great; context parenchymatous, sometimes including parts of the host plant at the margin as in a pseudostroma; spores fusoid, straight or curved, hyaline, guttulate, 7-8·5 x 2-2·5 microns; sporophores at first papillaeform, 10-15 x 1·5 microns, then more slender and longer, 20-25 x 1 microns, hooked, deciduous.

On apical and marginal spots on the leaves, and on dry and dying parts of the branches, of tea.

Curzi considers that this is probably the pycnidial stage of *Diaporthe theicola*, but he has not been able to confirm that.

Ascochytella theicola Curzi. Pycnidia epiphyllous, clustered, sub-superficial, obglobose, covered by the epidermis, then erumpent, 85-100 microns diameter; context parenchymatous, dark brown; ostiolum distinct; spores fusiform, acuminate at each end, one-septate, septum median, not constricted, 7-9 x 2·5-3 microns, yellowish; sporophores very short.

On marginal spots on dying leaves of tea. A weak parasite, occurring on leaves which are dying from other causes.

Septoria theicola Curzi. Pycnidia epiphyllous, scattered, covered by the epidermis, then slightly erumpent, globose, 70-90 microns diameter; ostiolum short, papillaeform, then open widely up to 60-75 microns diameter; context parenchymatous, thin, often pale yellow-brown, darker when dry; spores subfiliform, attenuated at both ends, hyaline, always one-septate in the middle, 10-15 x 1-1·5 microns, slightly curved, rarely straight.

On leaves of tea, in company with a species of Ramularia (see below), of which it appears to be the pycnidial stage.

Ramularia theicola Curzi. Spots greyish brown, subcircular, confluent in large apical or marginal patches, bordered by a wavy line; tufts epiphyllous, minute, clustered, with a small basal stroma, 30-35 microns wide; conidiophores hyaline, very short in nature but very long in a damp atmosphere, diverging fan-wise, simple or sometimes branched; conidia fusiform or cylindric, acuminate at both ends, varying in size, 5·5-12 x 1·5-2 microns, generally continuous, less frequently one or two septate, hyaline.

On leaves of tea. A weak parasite.

T. PETCH.

REVIEW OF MONTHLY REPORTS OF THE SCIENTIFIC STAFF, TEA RESEARCH INSTITUTE.

The following review relates to the progress reports for March, April and May, 1928.

The Mycologist reports that during the dry weather in March, several cases of the leaf disease of tea caused by *Phoma theicola* were recorded, in contrast to the corresponding month of the previous year, when the weather was wet and the prevalent leaf disease was Brown Blight. *Phoma theicola* has never shown itself to be a cause of serious disease.

Galls on the leaves of tea seedlings were recorded again in March. These are yellow or green swellings, usually along the mid-rib, which cause distortion of the leaf. It is believed that this phenomenon is the result of physiological disturbance, probably due to an excessive water supply combined with an abnormally high temperature. A similar development of galls on tea leaves reported from Nyasaland appears, from the description, to differ in some details.

A Septobasidium, similar to the Grey fungus of the Dadap of the Dutch East Indies, has been recorded on Dadaps in Ceylon. The fungus lives primarily on scale insects, but penetrates the cortex of the dadap stem to a slight extent.

Further attention has been given to Branch Canker, and examinations have been made of bushes which were treated three years ago by scraping out the wounds and applying a mixture of tar and Skene's wax. The results were quite satisfactory. On the other hand, filling cavities in the crown with a mixture of cement and sand had been unsuccessful.

Investigations on the death of bushes after pruning, usually attributed to the Diplodia root disease, have shown that the roots of such bushes are very often, if not always, deficient in reserve food, i.e., starch. From other examinations made by the Mycologist it has been found that the roots are the main storage region for starch in the tea bush; even seed-bearers show relatively little starch in the stems and branches. Healthy tea in plucking normally contains abundant supplies of starch in the roots, and this is also true of bushes attacked by Poria and other root fungi. The absence of starch from the roots of bushes which have failed to recover from pruning suggests that their death is due to a deficiency of reserve food, and that this is the real cause of very many of the deaths which are put down to Diplodia. The investigation of this subject is being continued from this point of view.

Observations on the field treatment of the Poria root disease have raised the question whether this fungus can live free in the soil, and experiments on this are being instituted.

An account of an Eelworm Disease of Dadaps was published in the *Tea Quarterly*, No. 2. Further investigations have shown that dadaps can become infected after planting out. On one estate, cuttings, 6 ft. long, were planted in 18 inch holes through tea, in 1926. This year these plants were found to be most heavily infected, having most probably been attacked as soon as the cuttings struck. It follows, therefore, that the soil of this estate is heavily infected with the eelworm.

The Agricultural Chemist has completed the arrangements for the uniformity trial on Scrubs Estate. The 144 plots have been surveyed and marked out, and the experiment is now in progress. Plucking is carried out under the personal supervision of the Agricultural Chemist and all weighings are made by him. Yields are tabulated on the basis of dry weight to avoid errors due to rain during plucking, and a method has been evolved which enables this to be done expeditiously. At the same time, from the determinations of dry weight on fine days, information will be obtained regarding the variation of the moisture content during the day and during the season. These latter determinations are being made by the Biochemist working in conjunction with the Agricultural Chemist. Examination of the data obtained is being done as the experiment proceeds.

A statistical analysis has been made of the data furnished by the co-operative liming experiments carried out in 1904-11. The data are unsatisfactory, in that they do not permit a direct estimation of error, but they do not support the view that lime in the quantities used in those experiments is harmful to tea.

Work has been continued on the physical properties of infertile tea soils. It is of interest that, so far, only one of the soils examined has been true to the lateritic type as defined by Mohr in his work on the soils of Java. The rôle played by organic matter in these soils has been investigated, and it has been found that it has an important relation to the buffer action of the soils.

The Biochemist has continued his investigations on the oxygen absorption of tea leaf, and has estimated the rate of respiration of tea leaf at one temperature by determining the rate of production of carbon dioxide. It has been found that the rate of production of carbon dioxide falls slightly during the so-called fermentation, which is contrary to what would be expected if the fermentation was due to micro-organisms. It has also been found that withered leaf is actively respiring, but at slightly lower rate than fresh leaf, so that leaf withered to a degree of 55 per cent. is still living. The ratio between the oxygen absorbed and the carbon dioxide evolved is practically

the same for both fresh and withered leaf. A change appears to take place in the leaf during withering, since the rate of respiration of withered leaf is retarded immediately it is crushed, whereas the rate of respiration of fresh leaf is not appreciably altered by that treatment. These investigations are being continued, and it is possible that they may provide a criterion of what is now termed " chemical wither."

Further experiments have been carried out with Carpenter's test for chemical wither, and one low country estate has been visited for that purpose. These tests are being carried out several times a week under the same, and varying, conditions, but the results obtained so far are very conflicting, and the two methods of conducting the test do not give concordant results. A sample of leaf withered for 28 hours very often gives a lighter colour than a sample of the same leaf withered for 20 hours, while frequently no difference is found between the infusion of fresh leaf and that of leaf after prolonged wither.

The investigation of the seasonal change in the composition of the leaf is being continued in collaboration with the Agricultural Chemist, leaf being obtained from the plots of the uniformity trial.

In the investigation of the seasonal changes in made tea, the preliminary work has yielded interesting data on the effect of time of brewing on the composition of the resulting infusion. The non-tannin constituents are the most easily extractable substances in the tea, and are almost completely extracted after five minutes contact with boiling water. These non-tannins contain the caffeine, 80 to 90 per cent. of which is extracted during the first four to five minutes of infusion, so that a longer draw results in increasing the quantity of tannin in solution without a corresponding increase in the other constituents. A similar effect is produced by pouring off the first infusion and adding a fresh supply of boiling water. The second infusion contains little caffeine, and tannin is present in excess over the non-tannins. The custom of allowing tea to draw for five minutes ensures almost complete extraction of the non-tannins, including the caffeine, without completely extracting the tannin. This is true for the various grades of tea, though the percentage tannin extracted in the same time varies.

The Entomologist has continued his investigations on methods of breeding the Tortrix parasite and its host, the grain moth, and has effected several improvements in apparatus.

Experiments on cutworms in a garden have been carried out with poison baits containing Paris Green and sodium silicofluoride respectively. Though the results cannot be expressed numerically, they appear to have been satisfactory, as no plants were destroyed in the treated plots after laying down the baits, whereas untreated beds suffered continual loss during the same period.

An extensive trial has been carried out on an estate near Nuwara Eliya to ascertain to what extent made teas would be tainted by spraying or dusting the bushes with insecticides. The substances under experiment were flowers of sulphur, sodium silicofluoride, kerosene-flour emulsion, and calcium cyanide. Part of the leaf from the treated bushes was manufactured separately, and part after mixing with an equal quantity, and with twice the quantity, of untreated leaf. Samples of the made teas were tested for tainting by a Colombo firm. The results are not very conclusive, probably owing to the fact that the small quantities of leaf have to be rolled by hand, and, despite all precautions to ensure cleanliness, the taint may be conveyed from one sample to the next. The greatest tainting effect was reported from the samples treated with sulphur and calcium cyanide respectively. Sodium silicofluoride apparently causes considerably less tainting, and kerosene-flour mixture the least effect of all. The samples prepared by mixing the treated leaf with untreated leaf differed very little from those prepared from treated leaf only. The fact that, of six control (untreated) samples, three were reported to be tainted, indicates the difficulties of carrying out accurate experiments on this problem.

Among the various pests recorded, the green Tea Weevil (*Astycus immunis* var. *bilineatus*), described in the *Tea Quarterly*, No. 2, has been found in one case to be causing considerable damage to dadaps and to the tea beneath them. Nettle Grub appears to have been unusually severe this year in the Passara and Badulla districts.

T. PETCH,

Director.

A NEW VIEW OF THE CAUSATION OF DIPLODIA DISEASE.

By

C. H. GADD, D. Sc.

One of the commonest diseases of tea in the low-country is that known as Diplodia. Affected bushes, though apparently quite healthy before they are pruned, fail to recover after this operation. In some cases, the bushes die without putting out any new shoots; in others, a few belated, rather weak shoots are formed, but these die back. Bushes which survive this critical period recover, and the disease does not occur till next pruning time.

The fungus, *Botryodiplodia Theobromae*, is usually to be found on the roots of such dead bushes. Because of its constant association with the diseased condition, mycologists have considered this fungus to be the cause of the disease, which consequently has become known as the Diplodia root disease of tea.

Botryodiplodia Theobromae, however, is a very common fungus in Ceylon. It may be found on a great variety of vegetable tissues which have been killed by other agencies. Its presence on dead tea roots, therefore, is no criterion that the fungus killed the roots unaided. In view of its ubiquity, its presence should suggest that the roots died of other causes, and that the fungus established itself on the dead tissues. At most, it would indicate that some adverse condition so reduces the vitality of the bush that the fungus is enabled to enter the living tissues and destroy them. The same argument holds in the case of other ubiquitous saprophytic fungi commonly found on dead tea bushes.

Three points concerning this form of Diplodia disease are worthy of notice:—

(1) The disease occurs only after pruning

(2) It occurs most frequently at mid and low elevations, where the plucking rounds are most frequent and the pruning cycle is shortest.

(3) Diseased bushes are scattered haphazard through the fields, and are not confined to definite areas from which the disease spreads, as is usually the case with diseases caused by parasitic root fungi.

These facts suggest that the disease results from physiological causes, rather than from the attacks of parasitic fungi. If a parasitic organism is in any way involved, its attack is limited to the period immediately following pruning. In that case, it is evident that the

operation of pruning in some way renders the bush susceptible to attack, and consequently, is a primary factor in the causation of the disease. The mere cutting of the branches alone cannot be the cause of the disease, nor can the operation so lower the vitality of the bush that the parasite is allowed entrance, else the disease would be prevalent at high elevations also, as neither pruning nor the fungus is confined to low elevations.

It would appear probable that climatic conditions play an important part in the causation of this disease, and that the condition of the bush at pruning time determines whether the bush will survive this operation.

A tea bush, when pruned, is normally denuded of leaves. The leaf is the factory in which the raw materials, obtained from the soil and the air, are manufactured into true foods, such as are found in seeds. Thus, when a tea bush is pruned, the manufacture of a food supply is stopped until such time as new leaves are formed to carry on this important work. Food, however, is required for the growth and development of new shoots and leaves. If a bush is to recover from pruning, the bush must have within it a sufficient reserve of elaborated food available for the development of its buds and the growth of new shoots and leaves. Until the new leaves are sufficiently developed to manufacture enough food for the bush's requirements, the bush must subsist on its reserves.

An abundant 'food supply' in the soil cannot make good any deficiency in the reserve of elaborated foods within the bush, when the bush is denuded of leaves. The food supply in the soil is raw material, and is of no immediate use to the plant until elaborated into organic foods. Moreover, the uptake of these supplies is dependent, to a large extent, upon the presence of leaves. The presence of an ample supply of reserve elaborated foods within the bush, when pruned, is therefore of the greatest importance. Without it the bush cannot recover.

The main reservoir for the storage of the reserve food supply is within the roots of the tea bush. Very little stored food is to be found in the stems. The chief constituent of these reserves is starch, which, being of primary importance and easily demonstrated, is the only one which need be considered here.

When tincture of iodine is applied to the surface of a root, cut transversely, the cut surface turns blue, almost black, if the root contains abundant starch. If no starch is present, the surface is stained yellow by the iodine. By means of this simple test, it is possible to determine whether a root possesses a store of starch or not.

Tests carried out on bushes, which have died of the so-called Diplodia disease after pruning, have shown that, in every case yet examined, the roots of the diseased bush are destitute of starch.

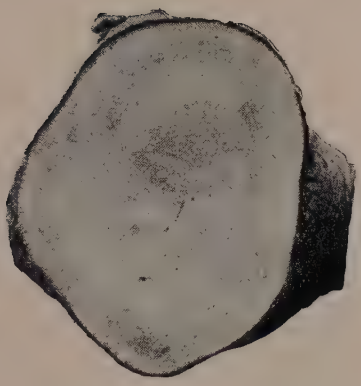

Fig. 1.

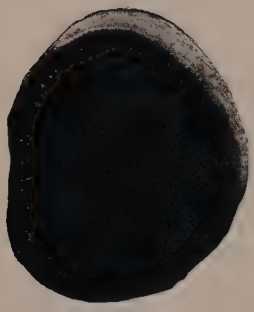

Fig. 2.

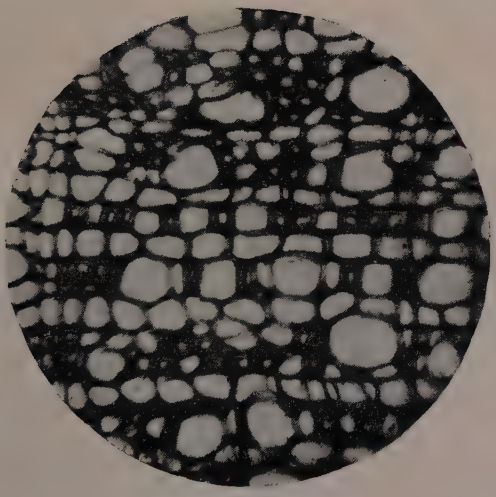

Fig. 3.

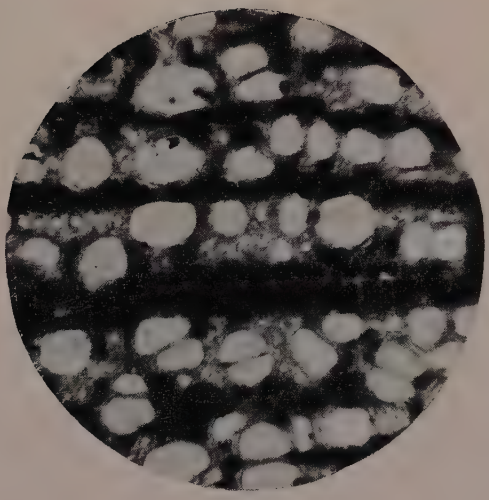

Fig. 4.

THE 'DIPLODIA' ROOT DISEASE OF TEA.

Healthy bushes, and bushes which have died of such diseases as are caused by Poria and Rosellinia, contain starch in sufficiently large quantities to be demonstrated by this test.

The absence of starch from bushes affected by the Diplodia disease is not the result of attacks by *Botryodiplodia Theobromae* or other fungi, as this condition is to be found in live roots, before they are attacked by fungi. It is more reasonable to suppose that death occurs when the reserve of food material is insufficient to support the life processes, or to furnish supplies for the development of new shoots and leaves after pruning. On the death of the roots, the tissues become invaded by Botryodiplodia and other saprophytic fungi, which at different times have been regarded as the cause of this disease.

On Plates VIII and IX are reproduced a number of photographs which illustrate the difference between healthy roots and those taken from bushes which have died after pruning (Diplodia disease). Figs. 1 and 2, Plate VIII, are of the cut surfaces of roots taken from Diplodia and healthy bushes respectively, and stained with iodine. The presence of starch in the healthy root is demonstrated by the dark colour of the treated surface. Figs. 3 and 4, Plate VIII, are micro-photographs of sections through smaller tea roots, stained with iodine. A comparison of these photographs shows that in a healthy root the starch is stored within particular cells, whereas the root cells of a Diplodia infected bush are destitute of starch. Figs. 1 and 2, Plate IX, are also comparable micro-photographs. These sections however, were not stained with iodine. The starch may be seen in Fig. 2 (healthy root) as definite granules which fill the storage cells. No starch grains are to be seen in the root from the Diplodia diseased bush (Fig. 1).

These observations afford a simple explanation of the cause of the death of tea bushes after pruning. A bush, which is destitute of starch at the time it is clean pruned, is incapable of making any further growth, though it may appear healthy and flush well before pruning. On the other hand, if there is but a very small reserve of food, the bush may begin to produce a few belated shoots which ultimately die back, if the supply is insufficient to bring them to a self-supporting stage. Bushes of this type are to be found in fields affected by the so-called Diplodia disease. Again, with a larger reserve of food, the bush will complete the development of its young shoots, the leaves of which, when capable of manufacturing enough elaborated food for immediate requirements, render the bush independent of its stored reserves. The whole of the symptoms observed in the field may thus be explained on the hypothesis that the cause of the disease is intimately connected with the state of the internal food reserves.

The importance of a reserve food supply has not generally been recognised. The great losses which occur annually after prun-

ing must be considered as a direct result of inadequate reserves. To prevent these losses it is necessary to treat the bushes culturally in such a way that they are enabled to store away such reserves as are essential for their recovery after normal pruning.

The application of manures at pruning time, as already explained, is of no immediate use to the bush; it cannot make good any deficiency of the reserve food, so long as the bush is without leaves. It is well known that affected bushes do not respond to manurial treatment. If manurial treatment is resorted to, the fertilisers must be applied some time, probably at least two months, before pruning is started. As a result of such manurial treatment, it is to be expected that the bush will flush well. The temptation to pluck hard, however, must be resisted; otherwise it is very unlikely that the store of reserve food will be materially increased.

The most obvious method of enabling the bush to build up a reserve is by resting it. The time necessary for the manufacture and storage of food in sufficient quantity for growth requirements after pruning, is at present unknown. The period for which badly affected fields should be rested, will have to be determined by experiment; no doubt, it will vary from district to district. For the present, it is suggested that one month's rest before pruning would have a beneficial effect on fields which normally show heavy losses after pruning.

A very light form of pruning should also be practised in affected fields. This should take the form of a light cut across, with the removal of some of the centre shoots if necessary. The object is to leave as much leaf as is possible on the bush, so that the manufacture of food supplies may be carried on without a break. This type of pruning cannot be continued indefinitely; after a number of such prunings, the bushes will have to be taken down or pruned normally. Under such a system, a heavy call on the food reserves is made at intervals of five or more years, instead of two years or less under the system at present in vogue, and the bushes should be in a better position to meet the demand.

The above suggestions regarding treatment are offered tentatively. The main object of this article is to draw attention to the importance of internal food reserves at pruning time. The deaths which occur at mid and low elevations, after pruning, and which are ascribed to the Diplodia root disease, are due primarily to a deficiency of such reserves.

It is very probable that several distinct diseases are known by the name Diplodia. Watt and Mann first recorded the occurrence of the Diplodia fungus in association with diseased tea in the Bishnath district of Assam. Young tea on grass land was dying out rapidly when 3 or 4 years old. "The leaves of the plant take a yellow

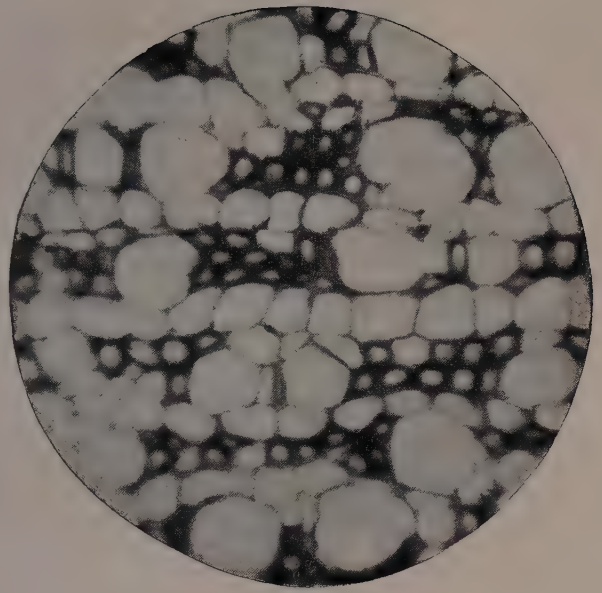

Fig. 1.

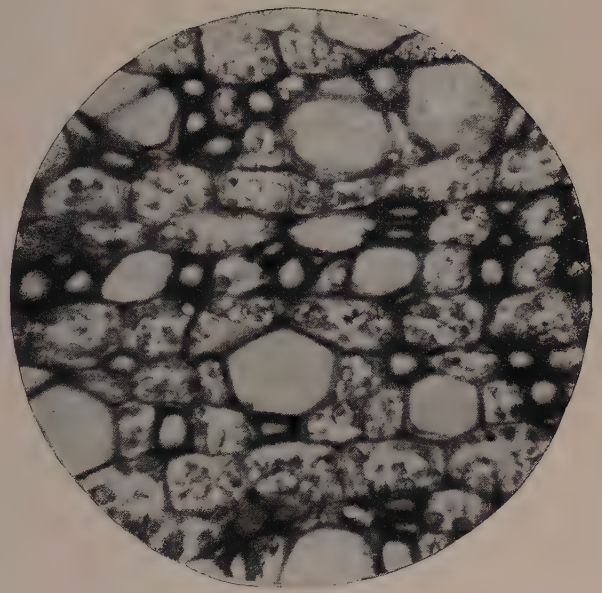

Fig. 2.

PLATE IX.

THE 'DIPLODIA' ROOT DISEASE OF TEA.

appearance, in which the network of the veins is very prominently seen (an appearance easily recognised after a little practice) and then they begin gradually to fall off and branch by branch the bush dies."

Dr. Butler, after examination of diseased material, ascribed the cause to the fungus Diplodia. Since then, the same fungus has been found associated with other diseases of tea, one of which is characterised by the death of the bushes after pruning in Ceylon. It is to this form of Diplodia disease that the above observations apply. As this disease is prevalent in certain districts in Ceylon, where it is well-known by the name "Diplodia disease," this name has been retained for the purpose of this article; but it would appear advisable to give this disease a distinctive name to distinguish it from the other diseases having different characteristics and with which the fungus, *Botryodiplodia Theobromae*, is commonly associated.

CHEMICAL WITHER.

By

D. I. EVANS

The reason for withering fresh plucked tea leaf before it can be made into black tea is primarily to obtain the leaf in a pliable condition suitable for rolling, so that the leaf takes a nice twist and no loss of juice occurs when pressure is applied in the roller. The loss of turgidity of the shoot depends on the loss of moisture, and the degree of wither is judged in various well-known ways, most of which are really tests of the turgidity of the leaf and stalk. There is some evidence, however, that time is a factor in withering, and experience supports the contention that the best wither is obtained when the requisite loss of moisture is attained in 18-20 hours, although claims are made that fine teas have been produced when the proper physical wither has been attained in a much shorter period. Consideration of time as a factor in the withering process apart from the loss of moisture has led to the belief that some chemical change takes place in the leaf on the tats, and, whether this is true or not, it has been the subject of several investigations in Java and India.

Deuss, who has carried out a considerable amount of work on the problems associated with withering in Java, and whose results unfortunately are little known in Ceylon, was not able to obtain any evidence of chemical changes during the process. He inclines to the opinion that the loss of moisture is the only change which goes on in the leaf on the withering tats. It is pointed out, however, that unless the wither is carried out with great care, chemical transforma-

tions take place to the detriment of the made tea. These changes are initiated by excessive drying, overheating, and damage caused to the leaf during plucking, packing in the baskets, and during the various processes it undergoes before it is spread out on the withering tats.

The Indian investigators contend that a chemical process takes place during the wither, and Mr. P. H. Carpenter informed the members of the various Tea Trade Associations in London that he had discovered a means of detecting the proper degree of chemical wither. He said:—"Today we have a very simple means of getting an approximate idea of what is happening. If the leaf that has been on the "chungs" or withering racks is infused, you will find that the colour of the liquor that you get from the leaf varies a great deal. In one case you will find that it is a light lemon colour, or even greenish, and it varies from that to the colour of Lyle's Golden Syrup. It is when you get the Golden Syrup colour that you know the chemical wither has taken place; any colour less than that means under-withering. If the process is continued further, you get over-chemical withering which gives a dull brown colour. It is usual in the latter case that the leaf also begins to develop colour. In all cases of proper withering, the leaf will remain green."

According to Carpenter, two methods are available for carrying out the test, the one most easily carried out being to infuse twenty undamaged shoots in a taster's pot with boiling water for 15 minutes before decanting the liquor, which should be a pale golden or ochre colour with no greenish tint, if a good chemical wither has been obtained, but will be pale greenish yellow if no chemical wither has taken place (Method A). The alternative method consists in dropping twenty shoots into $\frac{1}{4}$ pint of boiling water in a small saucepan, and keeping it in ebullition for 15 minutes before separating the liquor, which should be a bright golden, with a very slight reddish brown tinge (Method B).

There is no indication how these tests have been arrived at, and no proof has been submitted that such a colour change is any criterion of a complete chemical wither which is necessary for making good tea. It is, therefore, impossible to judge the value of the test except by trial, and repeated tests carried out in Nuwara Eliya and in other districts in the Island have given no indication of such a colour change, as will be seen from the following descriptions of the leaf used and the colours obtained. Owing to the difficulty of describing a colour in such a way as to indicate its shade and tint, the colours have been matched against Ridgway's Colour Standards, and his nomenclature has been adopted.

Method A.

Leaf Infused	Colour of liquor immediately after infusing	Colour of liquor after standing 24 hours.
Fresh leaf	Pale green-yellow	Pale green-yellow
Same leaf withered for 1 day	Pale Cendre-green	Barium yellow.
,, ,, ,, for 2 days	,, ,, ,,	,, ,,
,, ,, ,, for 3 days	,, ,, ,,	Light chalcedony yellow
,, ,, ,, for 2 days at 22°C.	,, ,, ,,	Barium yellow.
Partly withered leaf kept from further drying at 22°C for 3 days.	Pale dull green-yellow	Light chalcedony yellow

Method B.

Leaf Infused	Colour of liquor immediately after infusing.
Fresh leaf	Pale greenish yellow to light green-yellow
Same leaf after withering for 1 day	Chartreuse-yellow to citron-yellow
,, ,, ,, ,, for 2 days	Pale green to yellow

A golden syrup colour has never been obtained, the liquors even showing traces of green when obviously over-withered leaf was used for the infusion. The only marked difference between the liquor of fresh and withered leaf is that the liquor obtained from withered leaf tends to turn yellow on cooling. As this change of colour takes about 8-10 hours to develop, it can hardly be used as a test to determine whether the leaf is withered or not. This change of colour is being further investigated. Prolonging the wither produces no further change, so that the test does not give any indication of over-withering.

A golden coloured liquor can be obtained if the withered leaf is damaged in any way before being infused. Careless handling of the withered leaf while selecting shoots for infusion is generally sufficient to start the chemical changes, and if such damaged leaf is allowed to stand 3—4 minutes before adding the boiling water, then coloured liquors will be obtained. It may be contended that this indicates the leaf to be chemically withered, but unfortunately for that argument fresh leaf will also give yellowish brown liquors if crushed, and allowed to stand a few minutes before being infused.

The failure of the test in Nuwara Eliya might be due to some intrinsic property of the leaf, or that such a change is very slow under the cooler climatic conditions prevailing at this altitude, although this

seems to be disproved by the results of the experiments where partly withered leaf was kept for 3 days before being infused. The liquors obtained from this leaf did not differ appreciably from those obtained with fresh leaf.

When the test was tried under estate conditions at lower elevations, it was found that it was almost impossible to select undamaged leaf from the withering racks under factory conditions. One or other of the leaves attached to the shoot has been slightly damaged, or subjected to a greater drying than the rest, so that, on infusing, brownish patches are easily seen on the infused leaf, and the liquors obtained are coloured. It is necessary to draw attention to the necessity of selecting undamaged leaf for the test, for, if this is not strictly adhered to, a coloured liquor only indicates a degree of fermentation of part of the leaf, which should be avoided as far as possible if a bright uniform infusion is aimed at in the made tea.

The leaf used for the experiments was carefully plucked, and spread on the withering racks along with the rest of the day's pluck, so as to undergo the same treatment. When the necessary precautions are taken, tea leaf can be withered without any trace of colour appearing in the leaf, but at no elevation were golden coloured liquors obtained on infusing leaf withered in this careful manner. Leaf taken at random from the tats invariably produced coloured liquors, but, the leaf, however, showed reddish patches on examination.

The results obtained under estate conditions support the conclusion arrived at in the laboratory, that undamaged withered leaf of Ceylon tea does not give yellow coloured liquors when infused, and it is doubtful whether the coloured liquors obtained in India indicate anything but a particular condition of the leaf characteristic of that country. On informing Mr. Carpenter of my experiments, he writes:—"The test, I admit, is a very crude one and it is possible may only be applicable to the fast-growing succulent leaf that we obtain in mid-season, and then only under the high temperature conditions that we have for withering."

The effect of time on the wither can be explained on the hypothesis that the drying effect causes a concentration of the cell sap, so that the degree of dispersion of the cell constituents is altered. The increase in concentration thus affects the physical condition of the colloidal material of the leaf, with consequent changes in the permeability and the surface area which is of so much importance for cell oxidative processes. Since coagulation is affected by time and temperature as well as by changes in concentration, it will be realised that variations in the time taken and the temperature employed to attain the requisite loss of moisture will affect the degree of dispersion of the cell contents. The amount of surface available for oxidation will thus vary according to the manner in which the leaf has been withered, and the nature of the teas made will differ accordingly.

FACTS ABOUT FERTILISERS.

By

T. PETCH.

At the Agricultural Conference held at Peradeniya in May last, the discussion on several occasions centred on the subject of artificial manures, and the interest then aroused found expression subsequently in correspondence in the daily press. One correspondent objected that several erroneous statements were made at the Conference, an objection with which we would agree. It is inevitable that such must be the case at any Conference, as it is impossible to continue a discussion indefinitely, and it is equally impossible to reply to alleged facts of experiment without reference to the published accounts of those experiments. Consequently, it has been thought advisable to put forward here further evidence for or against some of the statements made.

Perhaps the statement which caused the greatest astonishment was the remark that "the chemical analysis of a soil on which tea is growing normally, as a basis of the composition of a manure mixture, is out of date." In support of that, a statement by Sir John Russell, in the *Annual Report on the Progress of Chemistry for 1921*, p.199, was quoted, viz.:—

> "One of the most difficult problems for the agricultural chemist is that of soil analysis. He is expected to analyse soils and on the basis of his results to give recommendations as to manuring. Unfortunately the problem is particularly difficult; in most cases insoluble on our present knowledge."

To the foregoing we may add the following extract from the Report on the Rothamsted Experimental Station in *Council Paper No. 80, Agricultural Research Council (Great Britain)*, 1926-27.

> "It is widely agreed that soil analysis would be very convenient if it could be made a trustworthy guide to farmers drawing up their manurial scheme; it would in fact have a far wider value. Unfortunately, present methods are of only limited utility, and they are not likely to be much improved till much more is known of the composition of the soil."

Turning to America, we quote the following from Lyon and Buckman, *The nature and properties of soil* (1922), p. 326:—

> "The conclusion that chemical analyses are of but little direct practical value as a guide to soil productivity is unavoidable. In spite of the great importance of chemistry in research and teaching, it fails to indicate either the permanent or the immediate fertility of the land."

But the idea is not a new one. Twenty-five years ago, Dr. A. W. Nanninga, who was then engaged on investigations on tea in Java, published a pamphlet, *The influence of the soil on the*

composition of the tea leaf and the quality of tea, Part 1. In it he wrote as follows, concerning investigations in Ceylon:—

> "It is known that soil analysis is not in a position to tell us what amounts of food materials are present in the soil in a form available to the plant, so that it appears to us very risky to decide from soil analyses alone what substances are deficient in the soil and in what amounts. Yet Bamber, on the basis of his soil analyes, prescribes for each estate the kind and quantity of artificial manure which should be applied."

Twenty-five years ago; and still the idea causes astonishment in Ceylon.

It must be particularly borne in mind that the foregoing quotations refer to chemical analysis of the soil as a basis for manuring. There are other methods of soil analysis, and these, as well as chemical analysis in general, have important applications. But the old ideas concerning the relation between the chemical analysis of the soil, or of the plant, and the composition of a manure mixture have had to be abandoned, and there is nothing at present to take their place. Research on the soil was never more actively carried on than at the present time, but, as regards manuring, the attitude of the soil investigator is one of hope, not of achievement.

In this connection, it may be noted that the recent Royal Commission on Agriculture in India vetoed the proposal that a soil survey of India should be undertaken.

The requirements of a plant can only be ascertained by carrying out manurial experiments with the plant, and observing the response obtained. It was suggested that this was empirical, but really it is quite the contrary. It is only by asking the plant that we can determine what the plant requires. On the other hand, manuring in accordance with a chemical analysis of the soil is empirical, as the methods of analysis are admittedly empirical (Russell, *Soil conditions and plant growth*, 3rd Ed., p. 208).

The query was raised how manure experts decided upon the mixtures recommended for manuring tea, if the chemical analysis of the soil was useless, and the answer was given that the mixtures were based on several years' experience. In subsequent correspondence, it was stated as a counter argument that the percentage of potash in a soil could not be determined by looking at a soil nor by experience. No one, of course, suggested that it could. The experience referred to in the reply in question was experience in tea manuring, i.e., knowledge of the effects of certain manures on tea yields.

The following records will afford material for reflection to those who pin their faith to the chemical analysis of the soil.

Tea on a certain estate was manured, for the first time, at the rate of 400 lb. per acre. In the following year, it was manured at the rate of 600 lb. per acre; and in the next year, at the rate of 800 lb. per acre. Obviously, if the chemical analysis justified the first application, it could not justify either of the others.

It was formerly customary to regard 30 lb. of nitrogen per acre as a maximum dose. That has now been increased, in some cases up to 120 lb. per acre. Here again, no chemical analysis can support this increase of a single constituent.

It is obvious that the recommendation of such manuring is not based on ideas derived from the chemical analysis of the soil, but more probably on the observed effect of the previous manuring on the yield of the estate.

It was stated that, whatever might be the deficiencies of chemical soil analysis, it had certainly shown that potash was necessary for coconuts. The example is an unfortunate one, for the method of determining "available" potash is a purely arbitrary one, and it is impossible to say that it really measures the amount available to the plant. We would suggest that the value of potash in coconut manuring has been learnt by the actual results of such manuring.

Numerous figures of the amount of potash in Ceylon soils have been quoted, but with regard to these a word of caution is necessary. It was customary, not so very long ago, to determine the potash in a soil by extraction with strong hydrochloric acid. Subsequently, it was realised that such a drastic method gave no useful information from the manurial standpoint, and dilute hydrochloric acid was substituted. Later, it was decided to adopt Dyer's method of extraction by means of a one per cent. solution of citric acid. Extraction by means of a strong acid gives what is known as the "total potash," whereas extraction with citric acid gives the "available potash." As already stated, the idea that the latter is available to the plant is purely arbitrary, and it lacks, as yet, scientific foundation. From the point of view of manuring, "total potash" has no meaning; "available potash" may have a meaning, but it is not established what that meaning is.

It follows that, in considering the available analytical data regarding Ceylon soils, attention must be paid to the date of the analysis. It would be of interest to know when the Dyer method was first adopted in Ceylon. Bamber's figures for tea soils in 1900 are evidently "total potash," and so are the figures for the Peradeniya tea plots in 1903. Bruce's analyses of Heneratgoda soils in 1905 give "total" and "citric soluble" potash, but Bamber's analysis of alkaline soil in 1908 does not. The idea is too modern to be exhibited by Cochran's analyses. It is not possible to make any valid comparison between these old figures and the figures obtained later by modern methods. "Available potash" cannot be deduced from "total potash," as there is no fixed ratio between them. The amount of "available potash" in a given soil may be anything from five to fifty per cent. of the "total potash" (Russell).

The figures for potash, obtained by chemical analysis of the soil, cannot, without further data, be taken to indicate that a plant grown on that soil will not respond to potash manuring.

One contributor to this discussion has remarked that the question of potash has "for some rather obscure reason, become a somewhat controversial one in Ceylon." The reason for that may possibly be found in the statements published by the same individual in 1926, that in all his experience of tea manuring he had found no case where any benefit had resulted from applications of potash, or where any harm had resulted from withholding them, and further that, in actual fact, Ceylon tea soils are quite well supplied with potash, and the growth of tea is not influenced by further additions. We are glad to have the later admission that these views have not been acted upon in practice, and the recognition of at least some of the effects of potash manuring.

As will be evident from a perusal of the standard text books on soils and manures, it is now well established that potash manuring has an effect on the foliage of a plant which renders it less susceptible to leaf diseases. It has also, in some cases, the effect of increasing the amount of reserve food stored up by the plant. As most of this work has been done in temperate climates, and the farm crops of temperate climates are grown, in general, as annuals, the foregoing effects have been the most noticeable. Now, however, that research in temperate climates has been extended to the manuring of fruit trees, further confirmation is being obtained of the fact, which before was regarded as chiefly of botanical interest, that potash favours the growth of wood. That the latter fact has not been referred to in text books on manuring is because those text books have, as a rule, dealt with the results of manuring annual crops.

These results of potash manuring have been indisputably established by scientific experiment, and they are beyond the attack of adverse propaganda.

Recently, the attention of Ceylon planters has been directed to the experiments on the manuring of fruit trees which are being carried on in England at Long Ashton and East Malling, as being in some respects analogous to tea manuring, and some far-reaching deductions have been drawn from them.

The particular Long Ashton experiment which has been cited deals with manurial experiments on apple trees, gooseberry bushes, black currants, etc., carried out from 1921 to 1924. These are what are known as deficiency experiments, that is, one set of plants receives potash, phosphoric acid, etc., but no nitrogen, another set, potash, nitrogen, etc., but no phosphoric acid, and so on; and to ensure the total absence of the missing element, the plants were grown in pure sand in pots and supplied with nutrient solutions con-

taining two of these chief constituents only. This type of experiment is viewed with disfavour by some investigators, because, though it does provide information on some points, it does not correspond to the conditions of actual manuring. In particular, it is quite probable that the two constituents supplied cannot show their full effect in the absence of the third, and the effect of the third may be out of all proportion to the quantity supplied, i.e., a very small amount of the missing element may have a large influence on the performance of the other two.

These Long Ashton experiments deal with the growth of shoots, development of leaves, etc., but their chief value is the demonstration they afford that a deficiency of potash favours the development of the physiological disease known as Leaf Scorch. Because of this, the accounts of the experiments deal principally with the effect of the manuring on the character of the foliage.

We are asked in Ceylon to "note that the effect of potash in the Long Ashton experiment is on the leaf and not on the wood. A great deal of nonsense has been talked in Ceylon about the effect of potash fertilizers on the growth of wood on the tea bush, and too little attention has been paid to their effect on the leaf. I put it to you that it is leaf you should watch for signs of potash deficiency and not the wood."

As already indicated, the effect of potash on foliage was well-known, and the Long Ashton experiments merely provide evidence of this effect in the case of fruit trees and shrubs. Their author's summary of his papers deals entirely with the problem of Leaf Scorch, and does not make any reference to the effect of potash on the development of wood. It is not permissible to read into a scientific paper more than its author claims to have proved, or provides data for, and it is quite wrong to deduce from the account of the Long Ashton experiments that the effect of potash is "on the leaf and not on the wood." The idea that because an experiment proves that potash has an effect on the leaf, it therefore follows that it has no effect on the wood is quite untenable. The published accounts of these Long Ashton experiments deal chiefly with the question of Leaf Scorch, and it must be concluded that the author was not especially concerned with the effect of potash on the development of wood.

We agree, however, that planters should watch the leaf for signs of potash deficiency, though it has not yet been established at what stage of deficiency that effect will be manifested on tea. That effect, however, is the easiest to observe, and it is what will strike the planter first, even if it is not the first effect on the bush. If the leaves have a general yellow tint, or if they develop a yellow margin, a deficiency of potash should be suspected. Signs are not wanting on several Up-country estates that this stage is being reached.

But it does not follow that the evident signs in the leaf are the first effect of a shortage of potash in the case of tea. That is another physiological problem which awaits investigation. It would be a mistake to assume that all is well with Ceylon tea, so long as the leaves do not show evidence of the symptoms which characterize potash starvation in other plants which have a more tender foliage.

As regards the effect of potash on wood, there are available the results of recent experiments on the manuring of apple trees carried out at East Malling from 1919 to 1927. These trees were planted out in 1913 and 1915 for a pruning experiment, and form forty sets of trees of different varieties under various pruning treatments. Records of crops, weight of prunings, number of shoots, girth of stems, etc., have been kept. In 1919, the whole plot received a potash manure (flue dust), in addition to dung, while during 1920—22 it received nitrogenous and phosphatic manures. Owing to the success at Long Ashton in treating Leaf Scorch with potasn, it was then determined to divide each set of trees into two plots, and to give one half a potash manure. Accordingly, in 1923, these half plots received 2½ cwt. sulphate of potash per acre, in addition to the manurial treatment of the whole. In 1924, the potash manuring was omitted, but in 1925, 1926, and 1927, the same half plots received 4 cwt. sulphate of potash per acre, over and above the general manurial treatment. We thus have a clear experiment, dealing with trees growing under ordinary conditions, all manured with dung, bones, guano, etc., while half of them received potash in addition.

We quote the results of this experiment, as far as they are relevant to the present discussion, from the *Journal of Pomology and Horticultural Science*, Vol. VII, p. 58.

> "The application of sulphate of potash to part of the Pruning Plot at East Malling has yielded very definite results. In comparison with the untreated trees, with a very few apparent exceptions, those which have received potash have shown :—
>
> (1) Very much less leaf scorch.
> (2) Greatly improved cropping, in both quantity and size of fruit.
> (3) Greatly increased growth, as indicated by increase in girth of stem, weight of prunings, and number of shoots.
> (4) A probable tendency, in certain exceptional cases, towards temporarily reduced cropping as a result of the greater vigour of the tree."

The third of these conclusions definitely indicates an increased growth of wood, both as increase in girth of stem and increase in number of shoots, as a result of potash manuring, and thus provides additional evidence in support of the "nonsense talked in Ceylon" about the effect of potash on the development of wood. On the other hand, the Long Ashton experiments quoted are not to the point.

One of the most serious problems of tea cultivation in Ceylon at the present time is that of promoting the growth of callus over old wounds (branch canker). True callus is chiefly wood, and evidence was obtained more than twenty years ago that callus formation was promoted by potash manuring. It is contrary to all botanical and experimental evidence to assert that such an effect is due to nitrogenous manuring and not to potash manuring. There is no valid evidence in support of that view.

Returning to the proceedings of the Agricultural Conference, we note that it was stated that:—

> "When he (the speaker) was in Java, he was given a book in which a larger number of soil analyses were included. No figures were given for potash. The author stated that they had satisfied themselves so thoroughly that the average soils in Java and Sumatra had sufficient potash that they did not even determine the potash in the soil analyses."

We take it that the book referred to is *Over de Theegronden van Java en Sumatra* (*The tea soils of Java and Sumatra*) by Dr. J. J. B. Deuss, *Meded. v.h. Proefstation voor Thee*, LXXXIX (1924). It contains a large number of soil analyses, and these do not include figures for potash. The reason for this omission is stated by Dr. Deuss on page 13, as follows:—

> "Waar kalicijfers weinig uitwezen, werd deze omslachtige en kostbare bepaling achterwege gelaten. Of dit op der duur vol te houden is, zal nog moeten blijken."

That is, "potash determinations have been omitted, because the method of determination is tedious and expensive, and very little can be deduced from them. Whether that attitude can be maintained permanently remains to be seen."

Again, Vageler, in *Archief voor de Theecultuur*, No. 2 (1928), p. 147, states:—

> "Kalibepalingen van bergcultuurgronden in Ned-Indië zijn nog gering in aantal, vooral ook door de omslachtige en dure methode met kalium-platina-chloride, die bij geringe hoeveelheden K_2O niet eens voldoende nauwkeurig is."

That is, "Determinations of potash in estate soils in the Dutch East Indies are as yet few in number, particularly because of the tedious and expensive method with potassium-platinum chloride, which is not sufficiently accurate in the case of small quantities of potash."

It will be evident that the reasons for the omission of determinations of potash from the analyses in question are quite different from that stated at the Conference. They were omitted because the method of determination is expensive and cumbersome, and the figures are not of much use when they are obtained.

NOTES ON ROOT DISEASES.

In De Bergcultures, 3rd Jahrg., No. 2, July 14, 1928, pp. 33—35, Dr. G. Gandrup states that he is often asked whether leaving the trunks of dead trees about an estate, or stumps in the ground, can have any direct influence in causing an attack of root disease in rubber or coffee. He notes that the presence of stumps of *Artocarpus elastica* has often been considered the cause of severe attacks of Brown Root disease, especially in new clearings. Consequently, he describes, and gives photographs of, two cases which show how a root disease fungus passes from a decaying stump to the roots of a living rubber tree.

In one case, the dead stump was that of a Lamtoro (*Leucaena glauca*). A lateral root of a neighbouring rubber tree ran across to the stump. This lateral was quite sound near its junction with the rubber tree, but the outer end near the Lamtoro stump was dead and decayed. The cause of the disease in this instance was the white root fungus (*Fomes lignosus*). All the other lateral roots of the rubber tree were found to be sound. Dr. Gandrup concludes that it is absolutely quite obvious that the Lamtoro stump was to be regarded as the source of infection.

In the second case, the dead stump was that of a rubber tree which had been felled for some unknown reason. The lateral root of a neighbouring living tree was in contact with a lateral root from the dead stump. The lateral of the living tree was attacked by *Fomes lignosus* from the point of contact for some distance towards the collar, but was quite sound near the collar. The remaining roots of the living tree were examined and found to be healthy.

On the ground of these cases, Dr. Gandrup considers it advisable to repeat the warning to planters against treating light-heartedly the question of stumps when trees have to be cut out on an estate. Although the expense is not inconsiderable, he is of opinion that all stumps should be dug out, together with their side roots.

That stumps serve as centres of root disease was evident to Ceylon planters nearly fifty years ago, when tea was first planted on a large scale, though, as recorded by Trimen, they then explained the fact by supposing that certain jungle stumps were poisonous to tea. During the rush into rubber, the replacement of cacao by rubber, and the subsequent thinning out of rubber, abundant evidence was afforded of the danger of leaving stumps to decay *in situ*, and at the present time there is no fact of plant pathology in the Eastern tropics so well authenticated as that stumps serve as centres of root disease.

For several years from 1905, root disease in rubber clearings was the general rule, and its connection with jungle stumps and timber was obvious. Of course, there were sceptics in those days, just as

there are at present, but it was usually possible to convince them by direct demonstration in the field. On one occasion, the mycologist, having demonstrated this on several fields of a rubber estate to a sceptical Superintendent, was walking with him along a path which ran obliquely up the hill side through a young clearing. At the lower side of the path stood a dead rubber sapling, and the Superintendent demanded, in forcible language, to be shown where the adjectival stump was. There was not a stump in sight. But on removing some of the lumps of cabook from the slope at the edge of the path, a fine crop of *Fomes lignosus* fructifications was revealed growing on the end of a jungle log which had been buried crosswise in the path. That settled the matter. The Superintendent refused to allow any further examination of the estate.

In those days, when nearly all the rubber consisted of new clearings with all the larger jungle stumps *in situ*, there was no difficulty in tracing the connection in very many cases between the roots of a jungle stump and the infected rubber roots. In later stages of the estates, whenever a group of two or three trees had died as the result of an attack of *Fomes lignosus*, it was generally possible to find cases in which the mycelium of the fungus had spread, often by contact, from the roots of the dead trees to those of neighbouring trees which were not yet sufficiently affected to show signs of the disease above ground.

Again, when Grevilleas in tea were cut out on mid-country estates, the course of the Grevillea roots, after a year or two, was indicated by lines of dead tea bushes, and it was easy to find cases in which either the tap root or the lateral of a dead tea bush was united to a Grevillea root by a cushion of mycelium of Ustulina. Similarly, when the cacao was cut out on a mixed cacao and rubber estate, leaving the cacao stumps *in situ*, Brown Root disease, and sometimes *Fomes lignosus* also, occurred commonly, and there was no difficulty in finding cases in which a root of a cacao stump was bound to a rubber root by the mycelium of the fungus.

Under normal conditions, root diseases in Ceylon occur most extensively in new clearings, whether rubber or tea. Consequently, they were very abundant from 1905 to 1910, when most of our rubber estates were opened. There was a recrudescence about 1912, when rubber estates were thinned out, and, in some cases, the stumps left *in situ* and the logs left lying about the estate. There is certainly less root disease at the present time, due to the fact that the estates are older and, in general, stumps and fallen timber have been removed. But it is difficult to believe that the sitution has now so improved that the connection between root disease and stumps, and the passage of a root disease fungus from one root to another, cannot be observed by anyone who wishes to see it.

It is satisfactory to have confirmation from Java to a fact which has been demonstrated to hundreds of Ceylon planters during the last twenty-four years.

Dr. Gandrup also records in the same article an experiment which shows that the Brown Root disease of coffee can be communicated to rubber by diseased coffee roots.

An iron barrel was filled with soil from a plot where no root disease was known to have occurred. The soil was taken from a field behind the laboratory which was originally old paddy land, and had been used since 1912 first for growing tobacco and subsequently for green manures. A root of a coffee bush killed by Brown Root disease was buried in this soil, and a rubber stump planted in the barrel on April 5th. After about fourteen days, the stump produced shoots, and on April 22nd these shoots were about 3 cm. long and appeared quite normal.

About a month later, May 28th, the young shoots began to wilt, but after watering they apparently recovered. On May 30th, however, the leaves again wilted and did not revive, and on June 5th they were almost dried out.

On taking up the rubber plant, the root was found to have been attacked by the Brown Root disease. The disease had passed from the dead coffee root to the Hevea.

T. PETCH.

CEYLON DISEASE FUNGI.

Bulletin No. 52 of the Department of Agriculture, Ceylon, having been out of print for some time, an enlarged edition has now been issued, the title being changed from *A preliminary list of the diseases of cultivated plants in Ceylon* to *A list of the fungi associated with diseases of cultivated plants in Ceylon*, Bulletin 83 of the Department of Agriculture.

The reasons assigned for this alteration are "that a list of the fungi which occur upon certain plants, usually in association with a diseased condition, is not the same thing as a list of the diseases of the plants. Apart from the fact that certain of the fungi listed in Bulletin No. 52 are not of common occurrence and others have not been proved to be the causes of diseases, the retention of the title of Bulletin No. 52 would perpetuate the mistake that fungus and disease are of necessity synonyms and inter-changeable terms."

As regards the last sentence we fear the alleged mistake is imaginary. As all systematic mycologists know, there are thousands of fungi which have never been considered to be the causes of disease.

Moreover, the previous title was "A list of diseases," and it is the general practice to list diseases under the names of the fungi which are supposed, until otherwise proven, to be the cause. As an illustration of the customary usage of terms, we would refer the compilers to the Bulletin entitled *Foreign plant diseases*, issued by the United States Department of Agriculture in 1926. As Bulletin 83 now stands, it includes several species of fungi which certainly do not cause disease.

The reference to the fact that certain of the fungi listed in Bulletin No. 52 are not of common occurrence is somewhat obscure, and we are at a loss to know what meaning is to be attached to it, relatively to the remainder of the sentence. Does it mean that if a disease is not common, it should not be included in the list? One of the objects in compiling Bulletin No. 52 was to acquaint mycologists in other countries with the fungi which were parasitic, or supposed to be parasitic, on cultivated plants in Ceylon, so that they might know what to guard against in introducing, into their respective countries, seeds or plants from Ceylon; and it is a matter of general knowledge that, among the fungi which have been transferred from one country to another, there are many which are considered rare or negligible, or had not even been recorded, in the country of origin. It may be noted that the United States of America prohibits the introduction of maize and allied plants from Ceylon, on account of a fungus, which, if it exists here, is so rare that it has not yet been found.

The inclusion of all the fungi found on any given plant in association with disease would result in a list of enormous length and little value. We note that in this respect Bulletin 83 does not carry out the promise of its title. A few saprophytic fungi which occur commonly on dead plants have been included, but the majority have been omitted. The Nectrias which occur on cacao have been included (these have been identified and their names might have been given), but no Nectrias are referred to under the headings Hevea and tea (Thea). *Polyporus zonalis* is recorded as occurring on coconut, but not on Hevea, while the equally common *Polystictus sanguineus* is omitted altogether. A consultation of the published lists of Ceylon fungi would have provided numerous other names. Under the heading, Vanilla, use might have been made of the paper on *The fungi associated with disease in Vanilla*.

In the new Bulletin, the fungi listed under each plant are classified as root fungi, stem fungi, leaf fungi etc. This has necessitated the transference of physiological diseases, and diseases due to bacteria or algae, to separate appendices. It has been overlooked that in this operation diseases due to lichens have somehow been omitted.

Under the heading, *Thea sinensis*, tea, the additions to the fungi enumerated in *The Diseases of the Tea Bush* include the root fungi, *Rhizoctonia bataticoia* (Taub.) Butler, *Fomes lucidus* (Leys.) Fr., and *Armillaria mellea* Vahl. As regards the latter, we are not aware that anyone has yet seen the fructifications of the rhizomorphs on tea, and the probability is that these rhizomorphs belong to the same fungus as those on Acacia, viz. *Armillaria fuscipes*.

Other fungi on tea enumerated in the new list are *Cytospora* sp., *Phomopsis* sp., *Coniothyrium* sp., and *Sphaerella* sp. These, however, were described in 1925 (*Additions to Ceylon fungi III. Ann. Peradeniya*, IX, pt. 3.) as *Cytospora Theae*, *Phomopsis Theae*, *Coniothyrium Theae*, and *Mycosphaerella Camelliae* respectively, and they should have been listed under those names. Reference to that paper would have revealed numerous other fungi, parasitic on tea and other plants, as well as others which are entitled to be included in a list of fungi associated with diseases. The additional entries in Bulletin 83 appear to have been taken from Administration Reports only, other sources of information having been neglected. It is to be regretted that the list has not been brought up to date.

Some of the omissions, in addition to those indicated above, are *Phoma glumarum* Ell. and Tr. on rice, *Ascochyta rosicola* Sacc., *Colletotrichum Ricini* Petch, *Colletotrichum Dracaenae* Petch, *Mycosphaerella Caricae* Syd. on papaw, and the Pestalozzias described on pp. 325, 326 (*loc. cit.*).

Dothiorella sp. on cherimoyer has already been named *Dothiorella Anonae*. The *Pestalozzia* sp. on cacao has been described as *Pestalozzia Theobromae*. The *Phytophthora* sp. on breadfruit has been identified as *Phytophthora Faberi*. *Pestalozzia* sp. on Eucalyptus is *Pestalozzia disseminata* Thuem. The Oidium on Hevea has been named *Oidium Heveae*.

It is generally agreed that it is a mistake to make, in a list of this kind, new alterations in names on the ground of alleged synonymy, as the reasons for such changes cannot be discussed in the list. Such alterations should be made in a separate paper, where the evidence for the change can be published in full. Included in a list, without evidence, they are merely arbitrary.

Thus, the name of the root fungus of *Acacia decurrens*, *Armillaria fuscipes*, has been changed to *Armillaria mellea*. The identification of this tropical fungus as the latter species has been based entirely on dried specimens, and it would not commend itself to anyone who is acquainted with the two fungi in a fresh condition. We take leave to doubt whether those responsible for this alteration have ever seen *Armillaria fuscipes*.

Again, the *Sclerotium zeylanicum* of the old list has been changed throughout to *Sclerotium Rolfsii*. But if the specimens

previously assigned to *Sclerotium zeylanicum* are considered identical with *Sclerotium Rolfsii*, the former name has priority.

In correcting the previous list, the name Sphaerella should have been changed to Mycosphaerella. This change, after several years of discussion, is now generally accepted by systematic mycologists. The citation, "*Sphaerella citrullina* (C. O. Sm.) Gros.", is an error.

On page 28, *Uromyces Mucunae* Babh. should be Rabh. On page 2, Boga medeloa should have one "l," and the name is not Malay.

T. PETCH.

INTRODUCED PESTS.

By

T. PETCH.

In the leading article in the Sunday edition of the *Times of Ceylon*, of December 4, 1927, reference was made to a bulletin of the United States Department of Agriculture, in which Mr. E. E. Green, late Government Entomologist of Ceylon, was quoted as stating that all the troublesome insects of this Colony are introduced species, and that not a single undoubtedly native species has attracted any notice as a pest.

In response to my query, the Editor of the *Times* kindly furnished me with the reference to the publication in question:—*U. S. Department of Agriculture, Division of Entomology. "The Laisser-Faire Philosophy applied to the Insect Problem"* by C. L. Marlatt. Reprinted from *Bulletin No. 20, Division of Entomology.*

That publication appears to be what is technically known as an author's separate. It is, as stated, reprinted from a Bulletin of the Division of Entomology, U.S. Department of Agriculture, and is the report of a Presidential address delivered before the eleventh annual meeting of the Association of Economic Entomologists on August 18, 1899.

The date is worthy of notice. It is prior to Mr. Green's appointment as Government Entomologist of Ceylon. Further, although twenty-eight years have elapsed since Marlatt's address, the United States Government has certainly not relaxed its efforts to prevent the introduction of injurious insects.

We are, however, chiefly concerned with tracing this alleged statement of Green's, concerning the injurious insects of Ceylon. Marlatt wrote, "So universally true is it that the newcomer will prove more destructive than the old familiar pests that this is looked upon

as a fixed principle, like the law of gravity. A good illustration of this is in the recent very valuable book by Mr. E. E. Green on the insects of Ceylon. Referring to the insects occurring on that island, he takes the position that excessive damage by an insect is a proof of its foreign origin."

The book referred to is apparently Green's *Coccidae of Ceylon*, the second part of which was published in 1899. In the introduction to that volume, Green certainly stated that "the very fact of extensive damage by any insect may of itself almost be accepted as proof of its foreign origin," but he was merely giving the current belief of that period, and he did not state it without qualification.

Incidentally it may be noted that although some introduced insects do cause more damage than native species, it is an error in logic to assume the converse, i.e., if an insect causes serious damage it is an introduced species. It may be queried whether, of the total number of insects which are introduced into any tropical country, the percentage of species which become pests is greater than that of the native species. Moreover, it must be remembered that our plantation crops are introduced plants. We introduce the foreign plant to the native insect.

Marlatt goes on to say, "He (Green) says that all the troublesome insects of Ceylon are introduced species, and that not a single undoubtedly native species has attracted any notice as a pest." But Green did not make that statement.

Green was writing a book on Coccidae (scale insects), and his statements refer to scale insects only. There is no doubt about that. The passage from Green's book, on which Marlatt based the alleged quotations in the foregoing paragraph, is as follows:—"Looking through the list of the different scale insects occurring in Ceylon I find that all the more troublesome species have been previously described from some other country, and are, therefore, presumably imported insects." And after giving a list of these, he adds, "On the other hand, not a single undoubtedly native species has attracted any notice as an insect pest in Ceylon."

It will be noticed that Marlatt ignored the fact that Green was writing of scale insects only, and, moreover, misquoted. Where Green wrote, "All the more troublesome *species* (i.e., of scale insects) .....are therefore presumably imported insects," Marlatt cited him as stating that "all the troublesome *insects* of Ceylon are introduced species,"—quite a different proposition.

There is no evidence that Shot-hole Borer, Tea Tortrix, Red Borer, *Calotermes militaris*, *Calotermes dilatatus*, Red weevil, Rhinoceros beetle, and other well-known pests of cultivated plants in Ceylon have been introduced.

NOTES ON TEA EXPRESSOR JUICE.

Dr. W. S. Shaw, the Tea Scientific Officer to the U.P.A.S.I., in his Administrative Report for 1927—28, reports an investigation of the losses sustained in the juice expressed from withered leaf by the use of an Expressor.

It is the custom on some estates in South India to use a tea expressor when a heavy crop is obtained or when the withering facilities are deficient. The advantages claimed for the expressor are:—

(1) Time of withering may be reduced.
(2) The appearance of the made tea is improved.
(3) Flakiness is reduced to a minimum.

The market price of the tea made does not seem to be affected by the use of the expressor, but the loss of bulk sustained is by no means negligible, as will be seen from the following data submitted in the Report.

Experiments were carried out on neighbouring estates with 300 lbs. of leaf withered to 60%, and the following losses were found on using the expressor:—

	Volume of Juice.	Total solids.	Tannin.
1st Expression	4·3 gals.	4·40 lbs.	1·76 lbs.
2nd Expression	1·5 ,,	1·305 ,,	0·535 ,,
Total	5·8 ,,	5·705 ,,	2·295 ,,

Shaw calculates the loss in bulk due to expressing on the approximation that 4 lbs. of unwithered leaf gives one pound of made tea, so that 300 lbs. of the withered leaf would give 115 lbs. of made tea. The use of the expressor thus results in the loss of 5·705 lbs. from 115 lbs. of made tea, which is equal to a loss of 5%. Further, assuming that the material extracted is the most soluble constituent, which would thus be extracted with boiling water, the loss of solids in the infused liquor must be considerable, and this is calculated as 24·8% of the solids in the liquid.

The author advises the exercise of caution and consideration before an expressor is installed.

D. I. EVANS.

REVIEW OF MONTHLY REPORTS OF THE SCIENTIFIC STAFF, TEA RESEARCH INSTITUTE.

The following review relates to the progress reports for June, July and August, 1928.

The Mycologist has made further examinations of tea bushes treated for branch canker with tar and Skene's wax on a mid-country estate where this mixture has been used for several years with apparently very good results. In this examination, attention was given more particularly to the results of treating large cavities, especially in the crown. The treatment adopted is as follows. The large cavities are first scraped out and then painted with tar and wax. The cavity is then filled with "sandstone," tightly packed down and finally painted with the mixture. Two years after treatment these fillings were found to be still firmly fixed in position, and the treated fields were found to be free from scavenging termites.

On one bush, treated in October, 1926, the main stem had been scraped out to a depth of five inches, and at the time of examination, nearly two years later, the wood surrounding the cavity was perfectly sound, with no discolouration to indicate an incipient decay. On another bush, treated in February, 1927, the result was not so successful; no further decay had occurred below the base of the cavity, but decay had progressed into the cavity from a diseased lateral branch.

As stated in the last review, bushes which fail to recover from pruning, and whose death is usually attributed to Diplodia, have been found to be deficient in reserve food, i.e., starch. The previous announcement of this fact was based on qualitative tests, as shown by the examination of sections microscopically and mass staining. Quantitative analyses of tea wood for starch are now being carried out, in order to establish this fact more accurately. At the same time the amount of sugar in the wood is being determined. The bush has to convert its starch into sugar, before the reserve food can be transferred from storage to the place where it is required for use, and it may happen that a bush which is deficient in starch may contain large quantities of sugar in process of translocation. The determination of both starch and sugar, therefore, gives a more complete picture of the state of the food reserves of the bush.

The results so far obtained indicate that bushes, dead or dying after pruning, are deficient in sugar as well as in starch, whereas a living bush, in leaf, contains a high percentage of sugar, even if the starch content is low.

Pestalozzia Lupini Sor. has been found attacking the leaves of lupins grown as green manure in a nursery. This disease is likely to be of less importance when the plants are more widely separated in the field.

The Armillaria sp., already recorded on young and old tea in Ceylon, has been found on the roots of a Hibiscus hedge.

A potentiometric apparatus for the determination of hydrogen ion concentration having been installed, the Agricultural Chemist has confirmed by this method the results previously reported concerning the "acidity" of the infertile soils under examination. Samples of soil have been obtained from areas where tea has been attacked by Rosellinia, and these are being examined in the light of recent work at Buitenzorg, where certain definite chemical characteristics have been attributed to such soils.

A survey of available soils with respect to exchangeable bases has been begun. The agricultural behaviour of a soil is largely the product of its colloidal activity. Tropical soils differ from temperate soils in respect of the type and reactivity of this important factor. It is the colloidal fraction of soils that is responsible for the retention of most of the plant nutrients, for their behaviour in cultivation, for their liability or otherwise to erosion, and for the state of reaction they exhibit. As one of the most fruitful approaches to the problem of the colloid complex is the study of the exchangeable bases associated with the colloidal constituents, work is being carried out on this subject.

The following results are to be regarded as tentative, pending the examination of further samples:—

(1) The few soils so far examined show a low value for exchangeable bases, compared with temperate soils.

(2) The total quantity of bases at saturation point is also low. Consequently, a soil may exhibit very little acidity, even when not profusely supplied with basic material.

(3) The saturation coefficient corresponds with the values quoted by Hissink for "old soils."

(4) Calcium does not supply such a large proportion of exchangeable bases to the total sum, as is usually the case in well-conditioned temperate soils. Magnesium is relatively more important.

(5) Organic matter increases the total amount of exchangeable bases and the amount which the soil could retain if saturated with respect to bases, but not necessarily the ratio of these two.

Work has been continued on the Uniformity Trial, seven pluckings having been made in the three months.

The Biochemist has continued the investigation of the seasonal changes in the green leaf, samples being obtained from the plots of the Uniformity Trial. With the closer control of the actual time of plucking, it has been found that the chemical composition of the leaf varies during the day. Leaf plucked later in the day contains a gummy substance which interferes with the precipitation of the tannin compound, and it has been necessary to modify the adopted method of analysis to meet his difficulty. Following up this, it has been found that:

(1) The total soluble material in the leaf increases during the day.

(2) The increase in the soluble material is very largely due to the gummy material which is precipitated by alcohol.

(3) There is an increase in the tannin during the day.

The following figures are given in illustration of this. They are the percentages of soluble extract obtained from leaf plucked at four different periods during the day.

	First period	Second period	Third period	Fourth period
Total extract ...	36·4	42·7	46·1	46·9
Precipitated by alcohol ...	0·0	2·4	4·0	6·7
Tannin ...	17·7	19·0	20·4	20·4

It would be interesting to know whether any difference has been observed in tea manufactured from morning and afternoon leaf respectively. Apparently there are no records on this point, probably owing to the fact that any difference would be masked by the bulking of the day's break.

Made teas from six estates are being chemically examined to determine what seasonal changes occur in the finished product. The moisture content of the teas analysed is about 6%, but there is considerable variation from month to month in samples from the same estate, the moisture content varying from 5 to 10%. This is probably due to the difference in the humidity of the atmosphere at the time of manufacture, as wet weather tea contains most moisture.

The onset of the wet weather is reflected in a smaller extract, due chiefly to a variation in the tannin content. At the same time, teas from the drier side of the hills show an increase in the tannin content.

Since a fixed quantity of tea is taken for tasting, it follows that more tea is actually used for the test when the moisture content is low than when it is high. Consequently, a stronger liquor, containing more solids and tannin in solution is obtained. As the wet weather teas contain less solids in the extract than dry weather teas, the high moisture content of the wet weather teas exaggerates their inferiority.

In co-operation with several estates, further trials have been made of Carpenter's test for chemical wither. This will be dealt with fully elsewhere, but it may be stated here that the test is not applicable under Ceylon conditions.

The Entomologist has been stationed at Mahagalla, Maskeliya, since July 1st. Owing to the difficulty of obtaining infested maize in July, the initial experiments were carried out with paddy, the common paddy moth being apparently the same species as that which attacks maize. The apparatus required has been planned out and some of it manufactured locally, but various delays have occurred in securing exactly what is required. Tea Tortrix began to be prevalent in July, and more than 12,000 egg-masses from different localities have been examined, in order to determine the degree of parasitism and the distribution of the parasites. Tea Tortrix has been reported from the Ambawela district and Rakwana.

The grub of a Longhorn beetle, much resembling that of *Batocera rubus*, which attacks rubber trees, has been found in tea bushes.

Tests with poison dusts, on Nettle Grub and Tea Weevil, show that, to both these pests ,Paris green is considerably more toxic than lead arsenate and sodium silicofluoride. The two latter show about an equal degree of toxicity, lead arsenate giving slightly better results with Nettle Grub, and sodium silicofluoride slightly better with Tea Weevil.

T. PETCH.

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Vol. I. Part 1. February, 1928.

THE

TEA QUARTERLY

THE JOURNAL

OF THE

TEA RESEARCH INSTITUTE

OF CEYLON.

Edited by

T. PETCH, B.A., B.Sc.

Director, Tea Research Institute.

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NUWARA ELIYA.

PRINTERS: H. W. CAVE & CO., COLOMBO.

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Correspondence regarding exchanges and papers for publication in the Journal should be addressed to the Director, Tea Research Institute, Nuwara Eliya.

E & A

Vol. I. Part 2. May, 1928.

THE

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ENTOM.

Vol. I. Part 3. August, 1928.

THE

TEA QUARTERLY

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IMP. BUR.
10 DEC. 1928
ENTOM.
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Vol. I. Part 4. November, 1928.

THE

TEA QUARTERLY

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OF THE

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